Health Information and Quality Authority

An tÚdarás Um Fhaisnéis agus Cáilíocht Sláinte

Potential impact of different serial testing scenarios using rapid antigen detection tests (RADTs) to detect SARS-CoV-2 in meat processing plant workers

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About the Health Information and Quality Authority

The Health Information and Quality Authority (HIQA) is an independent statutory authority established to promote safety and quality in the provision of health and social care services for the benefit of the health and welfare of the public.

HIQA's mandate to date extends across a wide range of public, private and voluntary sector services. Reporting to the Minister for Health and engaging with the Minister for Children, Equality, Disability, Integration and Youth, HIQA has responsibility for the following:

- **Setting standards for health and social care services** — Developing person-centred standards and guidance, based on evidence and international best practice, for health and social care services in Ireland.

- **Regulating social care services** — The Chief Inspector within HIQA is responsible for registering and inspecting residential services for older people and people with a disability, and children's special care units.

- **Regulating health services —** Regulating medical exposure to ionising radiation.

- **Monitoring services** — Monitoring the safety and quality of health services and children's social services, and investigating as necessary serious concerns about the health and welfare of people who use these services.

- **Health technology assessment** — Evaluating the clinical and cost-effectiveness of health programmes, policies, medicines, medical equipment, diagnostic and surgical techniques, health promotion and protection activities, and providing advice to enable the best use of resources and the best outcomes for people who use our health service.

- **Health information** — Advising on the efficient and secure collection and sharing of health information, setting standards, evaluating information resources and publishing information on the delivery and performance of Ireland's health and social care services.

- **National Care Experience Programme** — Carrying out national service-user experience surveys across a range of health services, in conjunction with the Department of Health and the HSE.

List of abbreviations used in this report

CI	confidence interval
COVID-19	Coronavirus disease 2019
Ct	cycle threshold
DAFM	Department of Agriculture, Food and the Marine
ECDC	European Centre for Disease Prevention and Control
FTE	full time equivalent
HIQA	Health Information and Quality Authority
HSE	Health Service Executive
HPSC	Health Protection Surveillance Centre
HTA	health technology assessment
NCPP	National Clinical Programme for Pathology
NPHET	National Public Health Emergency Team
RADT	rapid antigen detection test
RT-PCR	reverse transcription-polymerase chain reaction
SARS-CoV-2	Severe Acute Respiratory Syndrome Coronavirus 2
WHO	World Health Organization

Potential impact of different serial testing scenarios using rapid antigen detection tests (RADTs) to detect SARS-CoV-2 in meat processing plant workers

Key points

- Reverse transcription polymerase chain reaction (RT-PCR) is considered the gold standard test for the detection of SARS-CoV-2. When considering operational factors such as practicality, scalability, cost, and timeliness, rapid antigen detection tests (RADTs) may be a valuable addition to the suite of measures used to mitigate transmission risk.
- Meat processing plants have been associated with a considerable number of outbreaks of COVID-19 nationally and internationally. Serial testing in meat processing plants has been implemented in Ireland using monthly RT-PCR based testing of combined oropharyngeal / nasopharyngeal swabs collected by healthcare professionals.
- A validation study of an RADT has been completed in the context of meat processing plant workers engaged in serial testing in Ireland. The validation study compared an RADT based on mid-turbinate nasal swabs obtained by supervised self-sampling and processed on site by trained professionals with the current standard of laboratory RT-PCR based on healthcare provider-taken combined nasopharyngeal/ oropharyngeal swabs.
- This analysis, in the form of a modelling exercise, aimed to assess the potential impact of different serial testing scenarios using RADTs in meat processing plants in Ireland both in addition to and as an alternative to the current standard of practice (that is, monthly RT-PCR serial testing). The outcomes of interest from the model included estimates of the expected number of cases, potential infectious person-days in a plant, total number of staff days in self-isolation or restriction of movement, total number of cases detected (true positives) and associated number of false positives, number of tests conducted (both RADT and confirmatory RT-PCR), number of staff required to conduct testing, and cost of testing processes.
- Parameter estimates for the model were gathered from recent literature, previous HIQA evidence summaries, and Irish data sources (including contact tracing and RADT validation study results). A hypothetical cohort of

250 workers within a meat processing plant was simulated. For the RADT-based scenarios, the model assumed the implementation of supervised self-swabbing with a mid-turbinate nasal swab. It was assumed that this sample is provided to an individual who has undergone competency-based training for onsite-processing and reporting. It was further assumed that all positive RADTs would have confirmatory RT-PCR.

- A strategy of continued monthly RT-PCR testing with addition of serial RADT-based testing (that is a combination strategy) does not appear to add substantive benefit over a strategy based on serial-RADT-based testing (with confirmatory RT-PCR for positive results) alone.

- Of the RADT-based serial testing scenarios assessed (varied frequency from once a month to five times weekly without monthly RT-PCR), on balance, the use of RADT at a frequency of once or twice weekly appears to offer the largest benefits in terms of a potentially increased detection of cases, reduction in infectious person-days circulating, and a reduced overall cost relative to the current practice of monthly RT-PCR testing. Fortnightly RADT-based testing may offer comparable rates of detection, and infectious-person days circulating, at a reduced cost compared to current practice.

- The estimates presented within this analysis highlight that increases in the frequency of RADT-based testing are associated with increases in the detection of cases and reductions in potential infectious person-days in circulation. However, increases in the frequency of testing are associated with increases in overall cost, test processing staff requirements, and worker time spent in self-isolation or restriction of movements.

- Of note, while the total cost was estimated to be lower for a number of the RADT-based scenarios, the full-time equivalent staffing requirements for the implementation of testing processes on site was higher for RADT-based scenarios compared to current practice.

- There are important factors not accounted for within this analysis that should be considered within decision-making overall. These include the: acceptability of any change in testing to all relevant stakeholders, potential impact on productivity, training and availability of persons to implement RADT-based regimens, operational and logistical implementation of such testing regimens, in addition to requirements for clarity around operational oversight, clinical governance and quality assurance.

- There are a number of important assumptions and limitations which should be considered when interpreting the estimates presented within this report including: uncertainty around a number of key parameters, the context and historical nature of the data utilised, the heterogeneity of meat processing plants, the impact of vaccination roll out and the potential effect of variants of concern. The use of confirmatory RT-PCR for positive RADT results is an important assumption. In the absence of this assumption, a growing number of false positive tests are observed with increasing frequency of RADT-based testing, resulting in a greater number of days for the worker and close contacts unnecessarily spent in self-isolation and or restriction of movements. Such factors may negatively impact on engagement with such testing programmes. The analyses presented here have made no assumptions regarding on whom the cost of serial testing should fall.

- Given the specificity of the parameter data to meat processing plants, these estimates cannot be applied to other settings. The potential impact of such testing in other settings would need to be supported by validation work and epidemiological surveillance specific to the setting of interest.

- Overall, the estimates presented in this report suggest that RADT-based testing once or twice weekly may be a viable alternative to the current approach of once monthly RT-PCR serial testing in meat processing plants. Any such changes to the current strategy would need to be considered in the context of the assumptions and limitations within this report and further take into account factors related to acceptability, feasibility, operationalisation and clinical governance.

Potential impact of different serial testing scenarios using rapid antigen detection tests (RADTs) to detect SARS-CoV-2 in meat processing plant workers

The Health Information and Quality Authority (HIQA) has developed a series of evidence syntheses to inform advice from HIQA to the National Public Health Emergency Team (NPHET) and the Health Service Executive (HSE). The advice takes account of expert interpretation of the evidence by HIQA's COVID-19 Expert Advisory Group. This evidence synthesis relates to the following policy question outlined by the HSE Antigen Test Working Group:

> "What is the impact on transmission risk and resource requirements of different approaches to serial testing using rapid antigen detection tests (RADTs) in meat processing plants?"

This report summarises a modelling exercise to estimate the potential implications of using different RADT-based serial testing scenarios to detect SARS-CoV-2 in meat processing plant workers.

Background

Widespread vaccination against COVID-19 is underway in the European Union with the majority of member states initiating their vaccination programmes prior to the end of 2020.[1] While a number of candidate vaccines have been granted conditional marketing authorisation by the European Medicines Agency (EMA), and more are under evaluation or rolling review,[2] a limited supply of vaccines in the short to medium term has necessitated a prioritisation-based approach.[3] While expanding vaccine coverage is a key priority, testing and tracing to manage outbreaks remains a core element of the public health response to COVID-19.

Meat processing plants are considered to be an occupational setting in which outbreaks of COVID-19 are common and a considerable burden of infection exists for this sector.[4, 5] A recent analysis by HIQA (with data up to 27 February 2021) noted that outbreaks in meat processing plants were associated with 2,796 cases of COVID-19, representing a crude relative risk for infection in meat processing plant workers of 3.22 (95% CI 3.11 to 3.34) compared with the general population.[6] The outbreaks noted within these settings in Ireland are not unique, as extensive outbreaks have been documented in meat processing plants across Europe and internationally.[4, 5] The reasons for the elevated risk within these settings is likely multifactorial and context specific.[4] Factors such as shared accommodation, low wages, and the high number of migrant workers within the industry have been highlighted as potential contributing factors to introducing infection into the plant environment.[4, 5] Issues regarding income protection for employees within this

sector have further been raised by the Migrants Rights Centre Ireland and trade unions with estimates from mid-2020 of 90% of individuals not having access to sick pay. This may act as a disincentive to individuals from self-identifying when symptomatic.[7, 8] Factors such as reduced ability to social distance, cold air, limited ventilation and loud work spaces have been noted to potentially facilitate the transmission of the virus within the plant setting.[4, 5, 9-11] A report produced by the National Outbreak Control Team, investigating outbreaks in meat processing plants surmised that, with moderately high confidence, the amplification point for most outbreaks was within the plants themselves; though the complex nature of potential external interactions was highlighted.[10]

Extensive measures have been adopted by meat processing plants in an attempt to mitigate the potential for outbreaks in these settings with specific infection prevention and control (IPC) guidance provided by the Health Protection Surveillance Centre (HPSC),[12] and the rollout of serial testing programmes by the HSE in plants with more than 50 employees. In line with the national and international guidance, these serial testing programmes involve the use of the gold standard for the detection of SARS-CoV-2, that is, laboratory-based real time reverse transcription polymerase chain reaction (RT-PCR) based on combined nasopharyngeal specimens.[13-15] This form of test is noted to have considerable accuracy, in terms of both sensitivity and specificity.[14-16] However, there are a number of pre-analytical factors that may impact performance, such as the timing of specimen collection relative to disease onset, the population being tested, the type and sufficiency of clinical specimen obtained, and sampling and transport considerations.[16-19] While the actual testing processes associated with RT-PCR are not overly time intensive, the operationalisation and logistics associated with sampling and transport to laboratories result in a considerable increase in overall turnaround time.[14]

When considering operational factors such as practicality, scalability, cost, and timeliness, rapid antigen detection tests (RADTs) may offer a valuable addition to the suite of measures utilised to mitigate transmission risk.[13, 14]

RADTs detect viral antigens; this methodology does not involve the amplification of viral RNA associated with RT-PCR and hence is more simplistic in its operational requirements.[13, 14] However, these operational benefits come at a cost of reduced sensitivity with these tests typically having lower performance compared with RT-PCR, particularly in asymptomatic individuals.[13-16, 20] Of particular relevance is the timing of the test relative to exposure. Viral loads for SARS-CoV-2 in the upper respiratory tract typically peak one to three days prior to symptom onset and up to approximately five days post symptom onset.[14, 15, 21, 22] RADTs tend to have better detection capability in instances of higher viral load; typically performing well in those with Ct values less than or equal to 25.[13, 14] Therefore, particularly later in the disease course, RADTs may lead to lower rates of COVID-19 diagnosis compared

with RT-PCR. However, higher viral loads are typically associated with a greater infectiousness,[13, 14, 20] and while no reference standard test exists for the quantification of infectiousness,[20] the ability of a RADT to detect cases when there is a higher viral load is significant given these cases likely account for a considerable proportion of all transmission.[13, 14] As with all diagnostic tests, the pre-test probability of infection is a significant factor when considering the use of RADTs, with the presence of symptoms and known risk of exposure being important variables.[13, 14] The pre-test probability will also be influenced by overall infection prevalence, prevalence within the specific age-cohort, asymptomatic fraction, and the presence of factors that increase the risk of infection. The use of these tests in asymptomatic populations, particularly in those with an unknown risk of exposure or when there is low community prevalence requires careful consideration.[13, 14]

A range of RADTs are available, with variance observed in sensitivity overall.[14, 20, 23] Minimum performance criteria of ≥80% sensitivity and ≥97% specificity have been set by the World Health Organization (WHO) and the European Centres for Disease Control (ECDC),[14, 15] with the ECDC highlighting a target closer to ≥90% sensitivity and ≥97% specificity, especially in low prevalence environments.[14] The WHO further highlights the importance of appropriate training and competency levels for those involved in the performance of RADT-based testing (both sample taking and test processing), given the influence that such factors can have on test performance.[15] While viral loads can be similar in symptomatic and asymptomatic populations,[15, 24] manufacturer criteria typically guide RADT for use in symptomatic populations,[14] with these tests noted to have a generally lower sensitivity in asymptomatic populations.[20]

A growing number of countries in Europe are using RADTs with applications including testing of symptomatic populations, investigations of outbreaks, screening purposes, and, to a lesser extent, sentinel surveillance.[25, 26] The ECDC recommends that member states perform independent, setting-specific validation before implementation of RADTs.[14] Verification studies have been performed in symptomatic cohorts in Ireland by the National Clinical Programme for Pathology for a number of RADTs, with these studies resulting in the implementation of such tests in acute hospital settings and in outbreak settings in the community.[12] Of note, one such RADT using mid-turbinate nasal swabs has also undergone validation in workers in meat processing plants who are engaged in serial testing.[27] Consistent with findings of RADTs performance generally,[20] the validation noted higher sensitivity in symptomatic compared with asymptomatic populations, and progressively lower sensitivity with lower viral loads (Ct ≤25 versus ≤30 versus ≤35) in both populations.[27] Potential strategies to offset the reduced sensitivity of RADTs, include the use of repeat testing and or confirmatory RT-PCR.[13, 14]

The aim of this report is to assess, through a modelling exercise, the potential impact on transmission risk and resource requirements for different serial testing scenarios using RADTs in meat processing plants in Ireland.

Methods

A modelling exercise was undertaken to estimate the potential impact of serial RADT testing of workers in meat processing plants based on a range of pre-specified scenarios. Below is a summary of the four key elements underpinning the model: population, outcomes, scenarios considered and estimates for included parameters.

Population and setting

In line with current HSE serial testing programmes, this modelling exercise considers workers in meat processing plants (with at least 50 employees) undergoing serial testing for the detection of SARS-CoV-2. The outcomes of interest are presented for a hypothetical facility with a cohort of 250 workers followed over a single month. Each RADT scenario assumes a worker is supervised while self-swabbing to provide a mid-turbinate nasal swab and provides the sample to an individual who has undergone competency-based training to process and report the test.

Outcomes of interest

The model estimates the following clinical and organisational outcomes of interest, relative to the base case comparator of monthly RT-PCR serial testing, and also to no serial testing:

- expected number of cases
- total number of infectious person-days in circulation
- total number of staff days in self-isolation or restriction of movement
- number of cases (true positives) detected
- number of false positives
- number of RADTs conducted
- number of RT-PCR tests conducted
- resource requirements in terms of support staff to manage or supervise testing
- overall cost of testing processes.

Base case analysis and testing scenarios

The model considers the currently implemented serial testing programme of RT-PCR testing once a month as the base case (comparator). For completeness, a scenario of no serial testing that is, no RT-PCR or RADT serial testing is included; in line with current practice, this scenario assumes RT-PCR testing of symptomatic cases that self-identify and present for testing. Seven alternative scenarios are presented

comparing RADT-based serial testing at varying intervals with the base case. The scenarios considered are:

- Scenario one (comparator): serial testing with RT-PCR once a month.
- Scenario two: no serial testing (RT-PCR or RADT).
- Scenario three: serial testing with RADT once a month.
- Scenario four: serial testing with RADT once a fortnight.
- Scenario five: serial testing with RADT once a week.
- Scenario six: serial testing with RADT twice a week.
- Scenario seven: serial testing with RADT three times a week.
- Scenario eight: serial testing with RADT four times a week.
- Scenario nine: serial testing with RADT five times a week.

The seven alternative scenarios are also considered in conjunction with the base case (that is they are added to the current standard in Ireland) as a supplementary analysis (see Appendix 1, scenarios 10 to 16).

It is assumed that testing follows a regular pattern (for example, that weekly testing will typically fall on the same day each week). A positive RADT triggers a confirmatory RT-PCR test. RT-PCR is modelled as per existing testing through the HSE Test and Trace programme whereby a trained individual collects a sample with nasopharyngeal swabs and the swab is sent to a laboratory for testing. In all scenarios it was assumed that testing of close contacts of confirmed cases will be carried out using RT-PCR testing as per existing national guidelines. As per these guidelines, it was also assumed that workers identified as close contacts of confirmed cases are asked to restrict movements.

While the national guidelines around individuals who are symptomatic apply to workers in meat processing plants (that is, these individuals should not present for work and should self-refer for testing through the HSE Test and Trace programme), it is recognised that not all individuals that have symptoms adhere to this measure (for example, those with very mild or atypical symptoms or those that are concerned about potential loss of earnings). Therefore, the model assumes that a proportion of individuals that are symptomatic do not seek referral for testing through the existing national Test and Trace programme, and instead present to work where they may be detected during serial testing.

Model parameters

The model required a range of input parameters that describe infection, test, person, and organisational factors. Parameter estimates are typically defined by statistical distributions that reflect the uncertainty in their true values.

Infection factors

A summary of the parameter estimates for each relevant disease factor is provided in Table 1.

- Latent period

  The latent period is the period from exposure to becoming infectious. During this period, the individual is asymptomatic or pre-symptomatic and will not transmit the infection to others. There are very limited data to support an estimate of the latent period, and as such there is substantial uncertainty around the estimate.

- Duration of infectiousness (symptomatic cases)

  The duration of infectiousness is split into two periods: pre- and post-symptom onset. These two periods are when an infected individual's viral load is sufficient to transmit infection to others. Managing the period during which an individual is infectious is critical to controlling transmission of SARS-CoV-2. It is assumed that a person will not test positive prior to the infectious period. The pre-symptomatic infectious period is modelled as the difference between the incubation period and the latent period. The post-symptom onset infectious period is the duration of infectiousness once symptoms have developed. While it was assumed that a person was equally likely to transmit SARS-CoV-2 throughout the infectious period, it is highly likely that the profile of infectiousness changes over time. This is partly implicit in the data, as the duration of infectiousness is estimated from evidence of transmission over time. The available data also suggest that a disproportionate amount of transmission occurs before symptom onset, but this may be a reflection of reduced opportunity after symptom onset due to self-isolation of the index case. The reduced opportunity to transmit is explicit in the model as we assume all symptomatic and test-detected cases adhere to self-isolation.

- Duration of infectiousness (asymptomatic cases)

  This denotes the period that an asymptomatic individual is infectious, which commences once the latent period ends. The total infectious period for asymptomatic individuals was assumed to be equivalent to sum of the pre-symptomatic and the post-symptom onset infectious periods in symptomatic individuals.

- Secondary attack rate

  The reproductive number indicates how contagious an infectious disease is; that is, it represents the average number of people who will contract a contagious disease from one person with that disease. An individual's ability to transmit disease is a function of how many close contacts they have and whether any control measures were used (such as social distancing). Another important consideration is whether the individual is symptomatic and potentially restricting their interaction with others. The secondary attack rate is the proportion of people who were considered close contacts of the primary case who become secondary cases. A systematic review of secondary attacks rates for SARS-CoV-2 found that rates were higher in the home setting (0.21, 95%CI: 0.17 to 0.25) than in the average workplace setting (0.02, 95% CI: 0.00 to 0.04).[28] However, given that meat processing plants have been identified as a setting with a high risk of outbreaks, it is possible that the secondary attack rate in this setting is higher than for typical workplaces. As such, it was conservatively assumed for this analysis that the secondary attack rate in the workplace was the same as for the home setting. It should be noted that recent Irish evidence suggests a higher secondary attack rate in the home, potentially due to more transmissible variants, and a sensitivity analysis was carried out using a rate of 0.35 for close contacts.

- Proportion of asymptomatic infections

  Infected individuals may experience a range of symptoms of varying severity. Some individuals will experience no notable symptoms at all, and therefore may be unaware that they are infected unless detected through testing. Asymptomatic individuals can, however, transmit infection, creating challenges for the control of transmission. The parameter values are based on the findings of a systematic review,[29] and are consistent with the proportion of asymptomatic cases estimated in an Irish sero-prevalence study.[30]

- Percentage of non-infectious cases

  While it is recognised that not all cases will be infectious, a reference standard for the measurement of infectiousness is not established.[20] The concordance between RADT and RT-PCR is lower in individuals with high Ct values, that is, when compared with RT-PCR as the reference standard, RADT are less likely to be positive at higher Ct values, that is, there are a higher proportion of false negatives. A high Ct value indicates a low viral load at the time of testing and can imply that the individual is not infectious. The point in time nature of testing means that it is not possible to determine if an individual's peak Ct value was high enough to make them infectious. In the

absence of suitable data it was considered inappropriate to simulate viral load values. By not modelling Ct values, there could be a bias against RADTs as undetected cases will be considered infectious in the model. To account for this, the model incorporated estimates for the proportion of undetected cases that may have viral loads too low to be considered infectious based on Ct values greater than 30 at the time of testing. The proportion of cases with high Ct values was inferred based on testing results in RADT validation studies.[27] A sensitivity analysis was also completed to assess the impact of the proportion of cases that are non-infectious being higher than that assumed in the model.

- Background incidence

  The background incidence is defined as the incidence of sporadic cases amongst the workers in meat processing plants. This incidence was estimated by calibrating the model for the observed numbers of cases detected through monthly RT-PCR serial testing. From seven rounds of serial RT-PCR testing, 1,237 of 150,854 (0.8%) swabs tested positive for SARS-CoV-2. Assuming that the day of serial testing can be treated as random across facilities, it implies that on any given day 0.8% of workers are positive for SARS-CoV-2. Given the duration of infectiousness and the period over which an individual could test positive and the risk of disease transmission in the workplace, it implies a relatively high daily probability of sporadic cases. As an infected individual may present at work for a number of days before detection, if detected at all, then the rate of new cases each day must be less than 0.8%. A calibration exercise was used to determine a daily risk of 0.006 of being a new sporadic case, which equates to a 14 day incidence of 840 cases per 100,000. The alternative reason for the high rate of positive test results in the workplace could be a very high risk of disease transmission or a larger number of close contacts than suggested by the contact tracing data. As already highlighted, the workplace secondary attack rate used in the model was much higher than suggested for the typical workplace.

Table 1. Parameter estimates for infection factors

Parameter	Description	Source(s)	Estimate*
Latent period	The time duration (in days) from exposure to becoming infectious.	HIQA evidence summary of incubation period combined with LSHTM modelling estimate of latent period.[31, 32]	Mean: 2.7 (95% CI: 1.0 to 5.8)
Duration of infectiousness (pre-symptomatic)	The time duration (in days) from becoming infectious to symptom onset.	HIQA evidence summary of duration of infectiousness[33] combined with LSHTM modelling estimate of latent period.[31]	Mean: 3.8 (95% CI: 1.0 to 10.3)
Duration of infectiousness (symptomatic)	The time duration (in days) from symptom onset to no longer being infectious. Adjusted for proportional reduction in infectious individuals over time.	HIQA evidence summary of duration of infectiousness.[33] Singanayagam et al.[34]	Mean: 7.1 (95% CI: 2.7 to 11.4)
Duration of infectiousness (asymptomatic)	The time duration (in days) over which an asymptomatic case is infectious.	HIQA evidence summary of duration of infectiousness.[33]	Mean: 10.9 (95% CI: 5.2 to 18.7)
Percentage of household close contacts infected	The percentage of close contacts in a household with a case who subsequently test positive for SARS-CoV-2 RNA.	Thompson et al.[28]	Mean: 21% (95% CI: 14% to 29%)
Percentage of work close contacts infected	The percentage of close contacts working with a case who subsequently test positive for SARS-CoV-2 RNA.	Assumed to be the same as household. A lower value was tested as part of sensitivity analysis.	Mean: 21% (95% CI: 14% to 29%)
Percentage of asymptomatic infections	The percentage of all infected cases which remain asymptomatic (that is, they do not show symptoms at any point).	Buitrago-Garcia et al.[29]	Mean: 31% (95% CI: 24% to 38%)
Percentage of non-infectious symptomatic cases	The percentage of symptomatic cases who may have a viral load below infectious limits.	NCPP validation study (Ct values>30).[27]	Mean: 4% (95% CI: 0% to 10%)
Percentage of non-infectious asymptomatic cases	The percentage of asymptomatic cases who may have a viral load below infectious limits.	NCPP validation study (Ct values>30).[27]	Mean: 13% (95% CI: 7% to 21%)
Background incidence rate	The proportion of people in the cohort that are sporadic cases.	Inferred from the reported positivity rates for the existing programme of serial testing. While fixed in the main analysis, a sensitivity analysis explored the impact of alternate values.	Fixed: 0.0006

Key: LSHTM London School of Hygiene and Tropical Medicine; NCPP National Clinical Programme for Pathology

*Percentage estimates rounded to nearest whole number

Test factors

A summary of the parameter estimates for each relevant test factor is provided in Table 2.

- Sensitivity and specificity of RT-PCR testing for SARS-CoV-2

  RT-PCR is generally considered the gold standard for detection of SARS-CoV-2. As such, there are challenges to assessing the diagnostic test accuracy of the test. While high sensitivity and specificity are achievable, accuracy is affected by the stage of infection and the quality of the sample, among other factors. At early or late stages of infection, the viral load may be insufficient to trigger a positive test result. Swabbing from a single site or issues with storage and transportation of swabs can also impact on diagnostic test accuracy.

- Sensitivity and specificity of RADT testing for SARS-CoV-2

  The sensitivity and specificity of RADT is considered relative to that of RT-PCR. The parameters utilised reflect the results of validation work undertaken by the NCPP with variability in the estimates dependent on whether a case is symptomatic or asymptomatic.

Table 2. Parameter estimates for test factors

Parameter	Description	Source(s)	Estimate*
Clinical sensitivity of RT-PCR testing for SARS-CoV-2	Proportion of individuals with SARS-CoV-2 correctly identified as infected with SARS-CoV-2 by RT-PCR testing.	HIQA Rapid HTA of diagnostic tests;[16] inferred as high sensitivity when appropriate pre-analytical time factors satisfied.	Mean: 90% (95% CI: 84% to 95%)
Clinical specificity of RT-PCR for SARS-CoV-2	Proportion of individuals who do not have SARS-CoV-2 correctly identified as negative by RT-PCR testing for SARS-CoV-2.	HIQA Rapid HTA of diagnostic tests;[16] inferred as high.	Mean: 99% (95% CI: 98% to 100%)
Clinical sensitivity of RADT for SARS-CoV-2: symptomatic populations	Proportion of symptomatic individuals with SARS-CoV-2 correctly identified as infected with SARS-CoV-2 by RADT.	NCPP RADT validation results.[27]	Mean: 77% (95% CI: 69% to 85%)
Clinical sensitivity of RADT for SARS-CoV-2: asymptomatic populations	Proportion of asymptomatic individuals with SARS-CoV-2 correctly identified as infected with SARS-CoV-2 by RADT.	NCPP RADT validation results.[27]	Mean: 47% (95% CI: 36% to 56%)
Clinical specificity of RADT for SARS-CoV-2	Proportion of individuals who do not have SARS-CoV-2 correctly identified as negative by RADT.	NCPP RADT validation results.[27]	Mean: 99% (95% CI: 98% to 99%)

Key: NCPP National Clinical Programme for Pathology

*Percentage estimates rounded to nearest whole number

Person factors

A summary of the parameter estimates for each relevant person factor is provided in Table 3.

- Number of close contacts at home and in the workplace

  The contact tracing programme data was used to estimate the typical number of close contacts for individuals that were classified as part of outbreaks in meat or food processing plants. Of 3,182 notified cases from outbreaks in meat processing plants, 2,307 could be identified in the contact tracing data. Close contacts are categorised depending on the nature of the contact with categories including workplace, household and social. Half the listed contacts were uncategorised. Clearly these contacts could be redistributed across the categories in a variety of ways. With no redistribution, the mean number of close contacts was 0.33 in the workplace and 1.2 in the home. From the

perspective of plausibility, an average of 0.33 close contacts in the workplace suggests that for every three workers, one has a single close contact, and the remaining two have no close contacts at work. Even with a high secondary attack rate, outbreaks would be self-limiting because of the limited number of close contacts. For the main analysis, it was assumed that uncategorised close contacts were all in the workplace. By re-categorising unclassified contacts as workplace, the average in the workplace increased to 2.1 contacts. An alternative assumption was to redistribute them in proportion across all categories, which was tested in a sensitivity analysis. By proportionately redistributing unclassified contacts, the mean number of close contacts was 0.6 in the workplace and 2.5 in the home.

- Uptake of serial testing

  Participation in serial testing is not obligatory and workers may decline testing. Some may decline repeatedly and other may choose to avail of testing some of the time. Based on the experience of the RT-PCR serial testing programme, uptake has been 73% to date, although it was noted that uptake has been increasing over time. To account for the upward trend in uptake, a mean of 75% was used in the model with an upper bound of 82%. Depending on the frequency of serial testing and its acceptability to workers, high frequency testing may be associated with a lower uptake. In the absence of evidence to suggest the contrary, it was assumed that the same uptake would apply to both RT-PCR testing and RADT.

- Disclosure of symptoms

  Approximately 70% of individuals with COVID-19 develop one or more of a wide range of symptoms. Some people will, on developing symptoms, seek testing to determine if they are positive for SARS-CoV-2. However, many people may assume that their symptoms are not linked to COVID-19 and they may continue to go to work. From one HSE validation study of RADT in meat processing plants, both symptomatic and asymptomatic individuals were tested. Four percent of workers were symptomatic, of whom 19% were positive for SARS-CoV-2. It suggests that some workers continue to attend work while experiencing symptomatic infection. From an analysis of COVID-19 notification data for individuals that were part of outbreaks in meat processing plants, the proportion classified as symptomatic (64%) was much lower than for the general population (88%) or for people in outbreaks (83%). As a higher rate of genuinely asymptomatic infection is unlikely, it may reflect earlier detection, with notification occurring when the individual is still asymptomatic, and or reduced reporting of symptomatic status. For the

main analysis, it was assumed that 50% of symptomatic cases would not automatically seek testing for COVID-19.

Table 3. Parameter estimates for person factors

Parameter	Description	Source(s)	Estimate*
Number of household close contacts	The average number of household close contacts for a COVID-19 case.	HSE COVID-19 CMP data (specific to cases linked to meat processing plant outbreaks).	Mean 1.2 (95% CI: 0.0 to 6.0)
Number of work based close contacts	The average number of work based close contacts for a COVID-19 case.	HSE COVID-19 CMP data (specific to cases linked to meat processing plant outbreaks).	Mean 2.1 (95% CI: 0.0 to 7.0)
Uptake of serial testing	The percentage of individuals that agree to serial testing.	HSE serial testing programme for meat processing plants.	Mean: 75% (95% CI: 65% to 82%)
Percentage of symptomatic individuals that do not disclose symptoms	The percentage of individuals with symptoms consistent with COVID-19 infection who do not voluntarily come forward as symptomatic.	Approximated from HSE CMP data with wide range of uncertainty to assess impact.	Mean: 50% (95% CI: 22% to 78%)

Key: CMP Contact Management Programme
*Percentage estimates rounded to nearest whole number

Organisational factors

A summary of the parameter estimates for each relevant organisational factor is provided in Table 4. It was assumed that the lag from sample collection to test result for RT-PCR took two days. While the turnaround can be shorter, it was assumed that a worker would be sent home if they returned a positive RADT result and that they would not attend work the following day while awaiting the RT-PCR result.

Table 4. Parameter estimates for the testing process

Parameter	Description	Source(s)	Estimate
Average cost of RADT test	Indicative cost of a RADT test including the typical cost of the test kit, and staff time for supervising swabbing and processing test.	Approximation from multiple sources.	Mean €9.76 (95% CI: €7.33 to €12.62)
Average cost of RT-PCR test	Indicative cost of a RT-PCR test including the typical cost of test processing and staff time for swabbing and administration.	Approximation from multiple sources.	Mean €83.38 (95% CI: €68.04 to €99.37)

Model structure

A natural history model was used that simulates workers of a meat processing plant over an eight week period with results averaged to give a one month equivalent. Workers were classified into a series of mutually exclusive states (Figure 1) based on the progression of infection: not infected, latent period, infectious period (split into pre-symptomatic and post-symptom onset for symptomatic cases), in self-isolation/restriction of movements, and recovered. People that go into the self-isolation/restriction of movements states may or may not be infected; those who are not infected re-enter the 'not infected' state while infected cases move to the 'recovered' state.

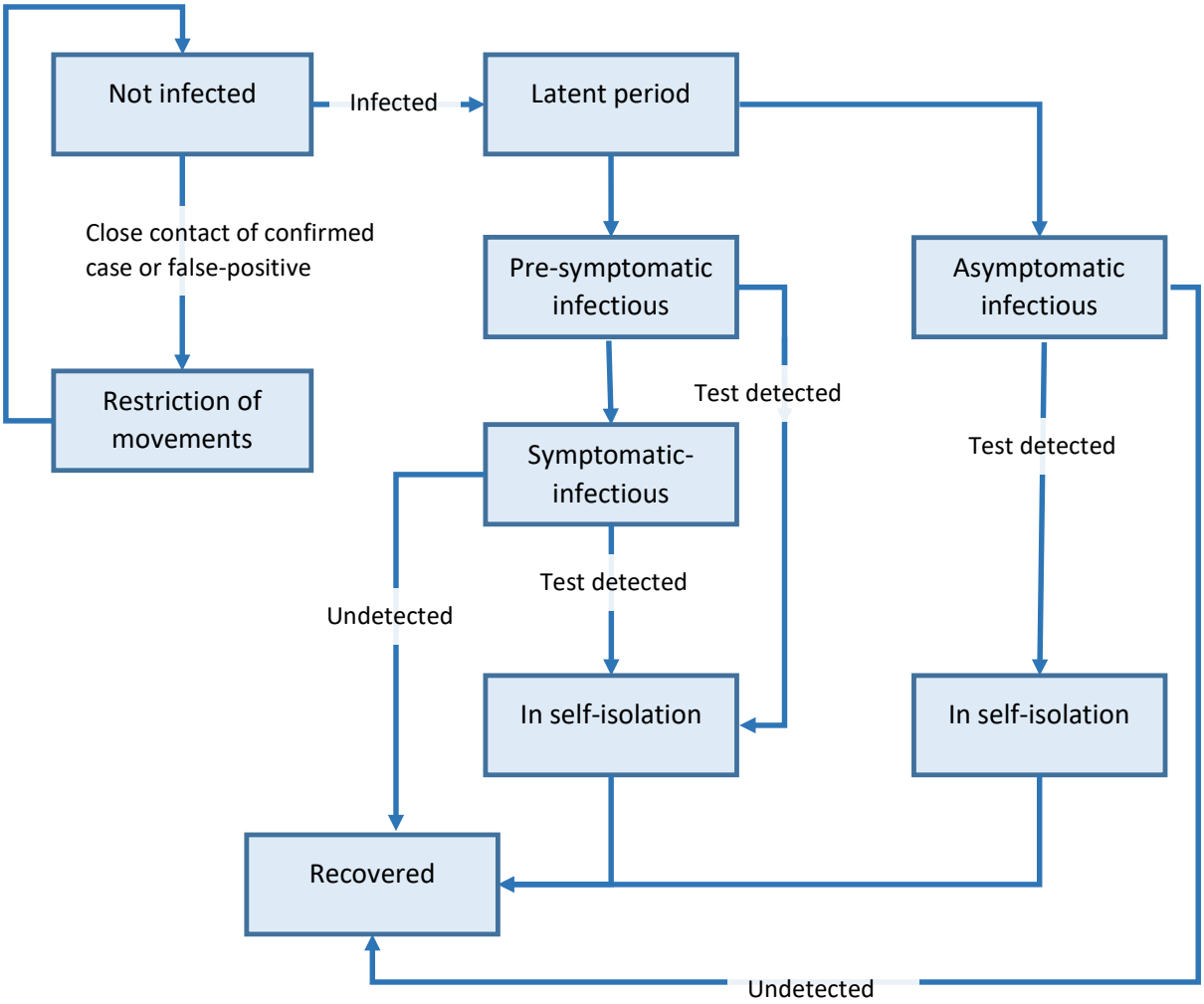
The model was structured as a series of functions. One function was used to generate the parameter values for use in the model. Parameters were split into individual-level and simulation-level variables. Individual-level parameters captured the variability in infection characteristics across cases. Simulation-level parameters captured population-level variables, such as test uptake and test performance. A separate function took the generated parameter data as an input and simulated the effect of different serial testing scenarios.

The model generated 10,000 workers, with a cohort of 250 randomly sampled for each simulation. For each of the modelled scenarios, individuals could change states in different ways depending on exposure to infection, disease progression, and the timing and accuracy of testing.

In each serial testing scenario, a proportion of individuals that became symptomatic were assumed to get tested and or be clinically diagnosed outside of the serial testing programme. Once diagnosed, symptomatic cases were assumed to self-isolate for the prescribed duration. Asymptomatic cases could only be identified through serial testing or testing as part of contact tracing. It was assumed that all

individuals identified as close contacts of an infected colleague would stay away from work for ten days and follow restriction of movements' guidance. All workers were treated as susceptible at the start of a simulation; recovered individuals were treated as immune and could not get re-infected during the rest of a simulation.

Figure 1 State transitions for the transmission model



All computations were carried out in R (4.0.4). Results are presented for a hypothetical cohort of 250 meat processing plant workers over one month. The model allowed all of the outlined parameters to vary across simulations. A series of sensitivity analyses were conducted to test structural assumptions in the model. A validation exercise was conducted to compare the modelled outputs against the existing programme of monthly serial testing using RT-PCR, with positivity rates based on the cumulative serial testing results to date (seven rounds of testing). The main outcome for validation was the positivity rate at testing.

In each simulation, a value is generated for each of the outcomes of interest. The values across 1,000 simulations provides a distribution for the outcome, with the mean reported along with the upper and lower 2.5th percentiles (which are reported as the 95% confidence interval). The uncertainty around the estimate for an outcome reflects the uncertainty around the input parameters and variability across individuals. The 95% confidence intervals should not be interpreted as a measure of statistical significance.

Results

Model results

The results of this analysis are presented by each of the key outcomes considering each scenario. Results are presented for a hypothetical facility with a cohort of 250 meat processing plant workers in a single month. The results presented here are based on RADT-based serial testing strategies as an alternative to the current approach of monthly RT-PCR. Supplementary results for scenarios considering RADT serial testing in addition to monthly RT-PCR testing are presented in Appendix 1.

Expected number of cases

The number of expected cases per scenario are outlined in Table 5. These estimates of the number of infected individuals include both those detected and not detected.

As shown, the highest number of cases is seen with scenario two for no serial testing with a mean of 8.2 cases (95% CI: 2.0 to 16.0). A stepwise reduction in cases is seen with increasing the frequency of RADT serial testing, with a frequency of fortnightly and above indicating a lower total number of cases (secondary to earlier detection and thereby reduced onward transmission) relative to the comparator. The lowest number of cases is observed with RADT testing five times per week (7.1 cases, 95% CI: 1.5 to 14.0).

Table 5. Total number of expected cases* (per hypothetical 250 worker cohort in a month)

Scenario	Total*		Incremental (relative to comparator)	
	Mean	95% CI	Mean	95% CI
1 (comparator): monthly RT-PCR	8.0	[2.0 to 15.5]	-	-
2: no serial testing	8.2	[2.0 to 16.0]	0.2	[-3.5 to 4.0]
3: monthly RADT	8.1	[1.5 to 16.0]	0.1	[-3.5 to 3.5]
4: fortnightly RADT	7.9	[1.5 to 15.5]	-0.1	[-3.5 to 3.5]
5: weekly RADT	7.7	[1.5 to 15.5]	-0.3	[-4.5 to 3.5]
6: twice a week RADT	7.5	[1.5 to 15.0]	-0.5	[-4.5 to 3.0]
7: three times a week RADT	7.3	[1.5 to 14.0]	-0.7	[-4.5 to 3.5]
8: four times a week RADT	7.2	[1.5 to 14.0]	-0.8	[-5.5 to 2.5]
9: five times a week RADT	7.1	[1.5 to 14.0]	-0.9	[-5.0 to 3.0]

*Total number of expected cases includes both those detected and not detected through testing

Person-days of infectious individuals in circulation

The more time an infectious individual is in the setting prior to detection, the greater the risk of onward transmission, and as such it can be interpreted as a measure of risk.

As shown in Table 6, the highest number of potential infectious person-days in circulation is observed with no serial testing in scenario two with a mean of 45 infectious person-days at work (95% CI: 8 to 100). Relative to monthly RT-PCR, the use of RADT at a frequency of at least fortnightly is associated with a stepwise reduction in infectious person-days relative to monthly RT-PCR with increasing frequency of RADT serial testing. The lowest number of infectious person-days is seen with RADT testing performed five times per week (19 infectious person-days per month, 95% CI: 3 to 42).

Table 6. Total infectious person-days (per hypothetical 250 worker cohort in a month)

Scenario	Total		Incremental (relative to comparator)	
	Mean	95% CI	Mean	95% CI
1 (comparator): monthly RT-PCR	40	[7 to 85]	-	-
2: no serial testing	45	[8 to 100]	5	[-20 to 35]
3: monthly RADT	42	[7 to 91]	2	[-24 to 26]
4: fortnightly RADT	39	[8 to 84]	-1	[-29 to 22]
5: weekly RADT	30	[5 to 64]	-10	[-41 to 14]
6: twice a week RADT	26	[5 to 56]	-14	[-48 to 8]
7: three times a week RADT	22	[4 to 48]	-17	[-52 to 6]
8: four times a week RADT	21	[4 to 47]	-19	[-56 to 4]
9: five times a week RADT	19	[3 to 42]	-21	[-57 to 2]

Number of true positive cases detected and number of false positives generated

The number of true positive cases detected through each scenario and the number of false positives generated are highlighted in Table 7. A false positive is defined here as an individual returning a positive test despite not being infected with SARS-CoV-2; in RADT scenarios it is the receipt of both a positive RADT and a positive confirmatory RT-PCR test despite not being infected. As noted, it is assumed that positive cases detected by RADT will be confirmed with RT-PCR testing.

As shown in Table 7, the lowest number of detected true positive cases is seen with scenario two of no serial testing; note, it is assumed that a proportion of symptomatic individuals will present for testing outside of the serial testing scenarios considered and hence cases will be identified in this scenario. A stepwise increase in the detection of true positive cases is seen with increasing frequency of RADT serial testing, with a frequency of fortnightly and above indicating higher case detection relative to the comparator. The highest number of true positive cases detected is observed with RADT testing five times per week with a mean of approximately 4.2 cases.

As expected, an increasing frequency of RADT serial testing is associated with an increasing number of false positive tests (Table 8). However, the majority of those false positives are identified as such through the use of confirmatory RT-PCR tests leading to a reduction in false positives relative to the comparator with all scenarios examined (Table 8).

Total number of person-days in self-isolation or restriction of movements

The total number of person-days spent in self-isolation or restriction of movement on the basis of a positive test result or as a close contact of someone with a positive test result is outlined for each scenario considered in Table 9.

As shown, the lowest number of person-days in self-isolation or restriction of movement is seen with scenario two of no serial testing (346 person-days, 95% CI: 0 to 875). Serial testing with RADT monthly, fortnightly or weekly is associated with a lower number of person-days in self-isolation or restriction of movement relative to the comparator. RADT testing at least twice weekly is associated with an increase in the number of person-days in self-isolation or restriction of movements relative to the comparator. Of note, this increase is likely reflective of the increasing number of cases detected with these scenarios relative to the comparator along with their associated close contacts, and an increasing number of false positives awaiting confirmatory RT-PCR testing.

Table 7. Total number of true positive cases detected and total number of false positives (per hypothetical 250 worker cohort in a month)

Scenario	Total number of true positive cases detected		Incremental* number of true positive cases detected		True positives as proportion of expected cases	
	Mean	95% CI	Mean	95% CI	Mean	95% CI
1 (comparator): monthly RT-PCR	2.1	[0.0 to 6.0]	-	-	0.24	[0.00 to 0.55]
2: no serial testing	1.4	[0.0 to 4.5]	-0.7	[-3.5 to 2.0]	0.16	[0.00 to 0.42]
3: monthly RADT	1.8	[0.0 to 5.5]	-0.2	[-3.0 to 2.0]	0.21	[0.00 to 0.50]
4: fortnightly RADT	2.4	[0.0 to 6.0]	0.3	[-2.5 to 3.0]	0.29	[0.00 to 0.60]
5: weekly RADT	3.5	[0.5 to 8.5]	1.4	[-1.5 to 5.5]	0.44	[0.08 to 0.77]
6: twice a week RADT	3.9	[0.5 to 9.0]	1.8	[-1.5 to 5.5]	0.51	[0.12 to 0.83]
7: three times a week RADT	4.1	[0.5 to 9.0]	2.0	[-1.0 to 6.0]	0.55	[0.20 to 0.88]
8: four times a week RADT	4.1	[0.5 to 9.0]	2.0	[-1.0 to 5.5]	0.57	[0.20 to 0.89]
9: five times a week RADT	4.2	[1.0 to 8.5]	2.1	[-1.0 to 6.0]	0.59	[0.25 to 0.89]

*Incremental relative to comparator. Process assumes that a positive RADT will be followed by confirmatory RT-PCR. A false positive is defined here as an individual returning a positive test despite not being infected with SARS-CoV-2. In the RADT based scenarios this is a positive RADT and a positive confirmatory RT-PCR test despite not being infected.

Table 8. Total number of false positive cases after RADT test and after confirmatory RT-PCR test (per hypothetical 250 worker cohort in a month)

Scenario	False positives after RADT		False positives after confirmatory RT-PCR			
	Total		Total		Incremental*	
	Mean	95% CI	Mean	95% CI	Mean	95% CI
1 (comparator): monthly RT-PCR	-	-	1.8	[0.0 to 5.0]	-	-
2: no serial testing	-	-	0.3	[0.0 to 1.5]	-1.5	[-4.5 to 0.0]
3: monthly RADT	1.2	[0 to 3.5]	0.4	[0.0 to 1.5]	-1.4	[-4.5 to 0.0]
4: fortnightly RADT	2.4	[0.5 to 5.5]	0.5	[0.0 to 2.0]	-1.3	[-4.5 to 0.5]
5: weekly RADT	7.1	[2.5 to 13]	0.7	[0.0 to 2.0]	-1.1	[-4.5 to 1.0]
6: twice a week RADT	11.6	[5 to 21]	0.7	[0.0 to 2.5]	-1.1	[-4.0 to 1.0]
7: three times a week RADT	16.1	[6.5 to 28.5]	0.8	[0.0 to 2.5]	-0.9	[-4.0 to 1.5]
8: four times a week RADT	20.4	[9 to 35.5]	0.8	[0.0 to 3.0]	-0.9	[-4.0 to 1.0]
9: five times a week RADT	26.9	[12 to 45]	1.0	[0.0 to 3.0]	-0.8	[-4.0 to 1.5]

*Incremental relative to comparator. For false positives after RADT, the total and incremental are the same because there are no RADT tests in the comparator.

The modelled process is based on the assumption that a positive RADT will always be followed by confirmatory RT-PCR. A false positive is defined here as an individual returning a positive test despite not being infected with SARS-CoV-2.

Table 9. Total number of person-days in self-isolation or restriction of movements (per hypothetical 250 worker cohort in a month)

Scenario	Total		Incremental (relative to comparator)	
	Mean	95% CI	Mean	95% CI
1 (comparator): monthly RT-PCR	613	[120 to 1,175]	-	-
2: no serial testing	346	[0 to 875]	-267	[-734 to 68]
3: monthly RADT	395	[2 to 958]	-218	[-652 to 59]
4: fortnightly RADT	438	[35 to 984]	-175	[-624 to 206]
5: weekly RADT	572	[106 to 1,175]	-41	[-515 to 413]
6: twice a week RADT	626	[110 to 1,232]	14	[-452 to 500]
7: three times a week RADT	666	[151 to 1,310]	53	[-428 to 566]
8: four times a week RADT	682	[165 to 1,324]	69	[-399 to 590]
9: five times a week RADT	726	[195 to 1,382]	114	[-350 to 612]

Number of tests conducted

The number of tests conducted per scenario are outlined in Table 10. These results are presented as RT-PCR and RADTs given the assumption that positive RADTs will be confirmed with RT-PCR.

The lowest number of tests performed is with scenario two of no serial testing in which the only tests performed are based on the number of symptomatic individuals presenting for testing outside of a serial testing programme and their identified close contacts (32 RT-PCR tests, 95% CI: 0 to 81). The subsequent results are as expected with higher frequencies of serial RADT testing associated with an increasing number of RADTs and confirmatory RT-PCR tests.

Table 10. Total number of RT-PCR and RADT tests conducted (per hypothetical 250 worker cohort in a month)

Scenario	Total number of RT-PCR tests^		Incremental* number of RT-PCR tests		Total number of RADTs	
	Mean	95% CI	Mean	95% CI	Mean	95% CI
1 (comparator): monthly RT-PCR	174	[126 to 229]	-	-	-	-
2: no serial testing	32	[0 to 81]	-143	[-192 to -100]	-	-
3: monthly RADT	36	[0 to 87]	-139	[-183 to -98]	118	[94 to 141]
4: fortnightly RADT	38	[0 to 92]	-136	[-182 to -92]	234	[188 to 278]
5: weekly RADT	50	[7 to 105]	-125	[-174 to -71]	689	[569 to 792]
6: twice a week RADT	54	[9 to 111]	-120	[-172 to -72]	1,128	[930 to 1,306]
7: three times a week RADT	55	[10 to 109]	-120	[-169 to -68]	1,564	[1,298 to 1,816]
8: four times a week RADT	56	[10 to 114]	-118	[-170 to -66]	1,981	[1,629 to 2,315]
9: five times a week RADT	59	[11 to 114]	-115	[-164 to -62]	2,617	[2,145 to 3,050]

^The total number of RT-PCR tests is a function of the number of workers present for testing, the uptake of testing, the number of close contacts tested, and the number of confirmatory RT-PCR tests required where RADT was used.

*Incremental relative to comparator. Process assumes that a positive RADT will be followed by confirmatory RT-PCR.

Number of staff required to conduct testing

The full time equivalent (FTE) staff required for each testing scenario is outlined in Table 11. As noted, the RT-PCR comparator is associated with staff required on site to collect specimen samples, while the RADT scenarios are associated with supervised self-sampling of nasal specimens and staff on site to process and report the tests.

Given the time difference associated with specimen collection versus completing RADTs, as shown there is an incremental rise in the FTE required for all RADTs relative to the comparator. The highest requirement is seen with scenario nine of RADT performed five times per week (3.01 FTE, 95% CI: 2.26 to 3.89).

Table 11. Number of FTE staff (per hypothetical 250 worker cohort in a month)

Scenario	Total		Incremental (relative to comparator)	
	Mean	95% CI	Mean	95% CI
1 (comparator): monthly RT-PCR	0.16	[0.11 to 0.23]	-	-
2: no serial testing	0.03	[0.00 to 0.07]	-0.13	[-0.19 to -0.09]
3: monthly RADT	0.17	[0.12 to 0.22]	0.00	[-0.05 to 0.05]
4: fortnightly RADT	0.30	[0.23 to 0.39]	0.14	[0.06 to 0.22]
5: weekly RADT	0.83	[0.64 to 1.05]	0.66	[0.48 to 0.88]
6: twice a week RADT	1.33	[1.01 to 1.68]	1.16	[0.86 to 1.53]
7: three times a week RADT	1.82	[1.39 to 2.34]	1.65	[1.23 to 2.18]
8: four times a week RADT	2.29	[1.73 to 2.98]	2.13	[1.57 to 2.80]
9: five times a week RADT	3.01	[2.26 to 3.89]	2.85	[2.11 to 3.74]

In terms of the resource requirements, 21,876 staff of meat processing plants have been included in monthly RT-PCR serial testing to date. That is 87.5 times the cohort used in the model. Based on the estimates presented here, it requires approximately 14 FTEs to deliver the existing serial testing programme. If all components of an RADT-based serial testing programme were provided by the HSE, a change to once weekly RADT serial testing, for example, will require an estimated 73 FTEs to provide the required coverage. A once weekly RADT scenario would also require approximately 60,300 test kits a month and would generate around 4,400 RT-PCR tests.

Cost of testing processes

The total cost of testing per scenario (irrespective of whether the payer is HSE and or meat processing plant) is presented in Table 12. Of note, these estimates include

the cost of test kits, staff time, and the laboratory costs associated with RT-PCR tests.

As shown, an incremental reduction in cost is seen for RADT serial testing relative to the comparator for scenarios up to a frequency of three times weekly. At a frequency of greater than three times weekly, an incremental increase in cost is seen relative to the comparator.

Table 12. Cost of testing processes (per hypothetical 250 worker cohort in a month)

Scenario	Total (€)		Incremental (relative to comparator) (€)	
	Mean	95% CI	Mean	95% CI
1 (comparator): monthly RT-PCR	14,542	[9,844 to 20,064]	-	-
2: no serial testing	2,638	[0 to 6,751]	-11,904	[-16,847 to -7,879]
3: monthly RADT	3,707	[727 to 8,023]	-10,835	[-15,288 to -7,053]
4: fortnightly RADT	4,593	[1,493 to 8,813]	-9,949	[-14,623 to -6,060]
5: weekly RADT	8,340	[4,557 to 13,088]	-6,202	[-10,944 to -1,802]
6: twice a week RADT	11,382	[7,037 to 16,607]	-3,160	[-7,825 to 1,576]
7: three times a week RADT	14,081	[9,333 to 20,175]	-462	[-5,883 to 5,228]
8: four times a week RADT	16,764	[11,453 to 23,350]	2,222	[-3,704 to 8,845]
9: five times a week RADT	20,858	[14,088 to 28,844]	6,316	[-530 to 14,600]

Collective interpretation of results

To provide a balanced view of the estimates provided above when considering serial testing with RADTs, it is useful to consider the outcomes collectively. Figure 2 shows the relative impact of different scenarios on costs and cases avoided. The number of cases avoided is the reduction in total cases relative to having no serial testing in place. Figure 3 below outlines the number of tests completed (RADT and RT-PCR) relative to the number of cases detected. As shown, a stepped increase in cases detected is seen with the use of weekly RADT testing relative to the comparator of monthly RT-PCR testing. Beyond this frequency, a progressive increase in cases detected is observed but with a lower rate of change.

Figure 2. Cost of serial testing versus cases avoided (per hypothetical 250 worker cohort in a month)

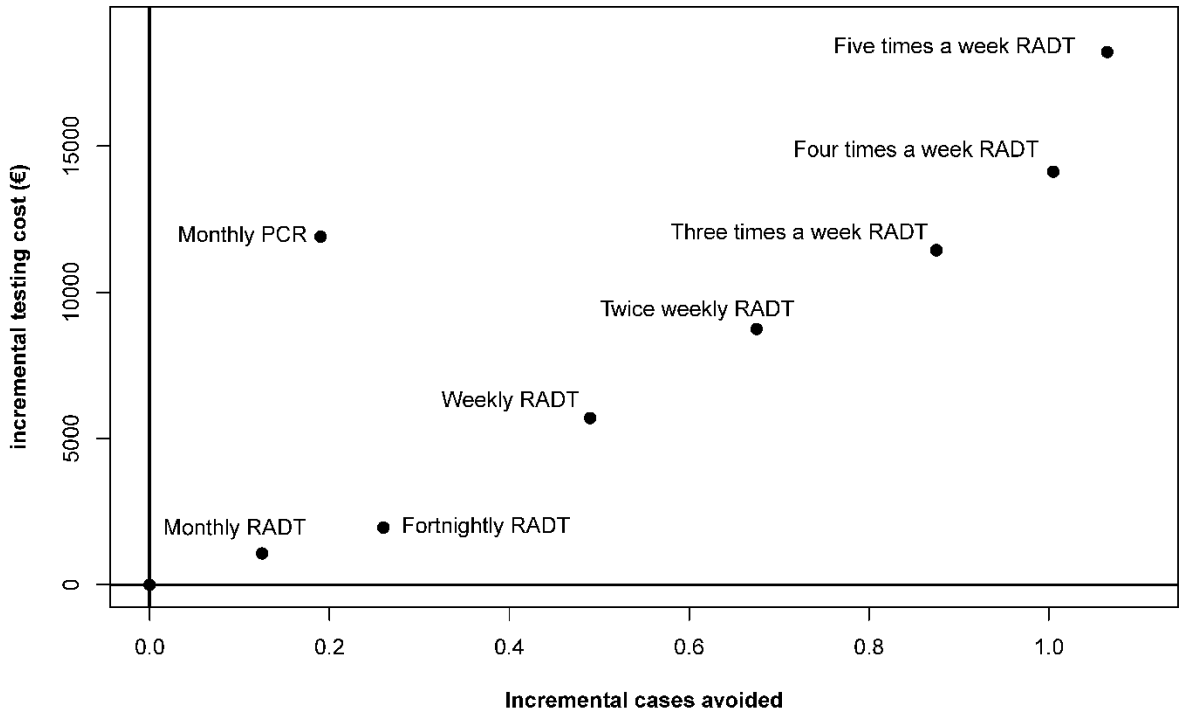


Figure 3. Cases detected versus number of tests completed (per hypothetical 250 worker cohort in a month)

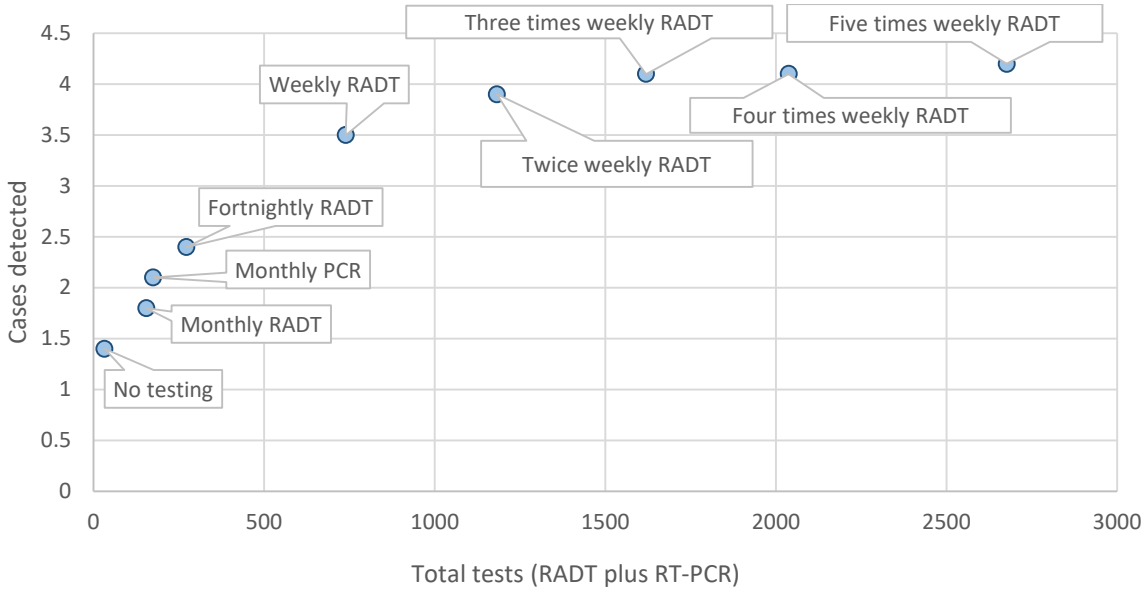
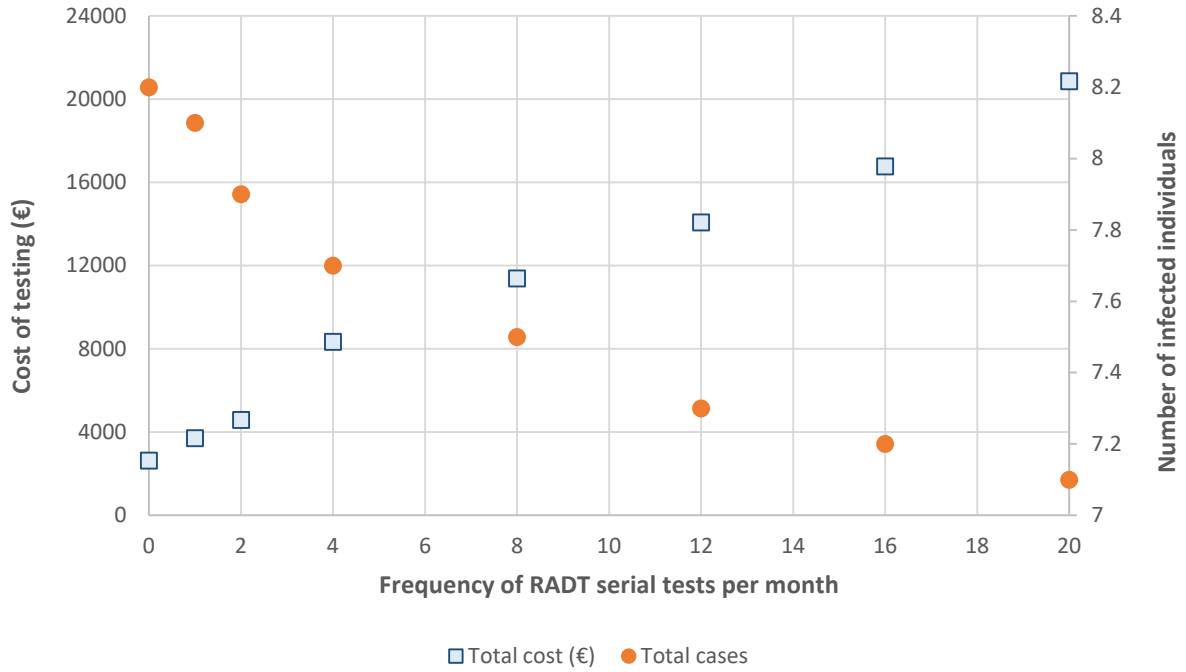


Figure 4 presents the number of infected individuals versus the cost of testing, across the number of RADTs completed. As shown, a benefit is seen in terms of the reducing number of infected individuals (secondary to detection of cases) with a convergence of cost and benefit seen for RADT testing twice weekly. A diminishing return in terms of identified cases is observed with a widening gap in terms of cost with higher frequency of testing. The cost of testing and number of infected individuals are not equivalent outcomes, and therefore the intersection of the two data series should not be interpreted as an optimal frequency of testing.

Figure 4. Number of infected individuals and cost of testing by frequency of RADT testing (per hypothetical 250 worker cohort in a month)

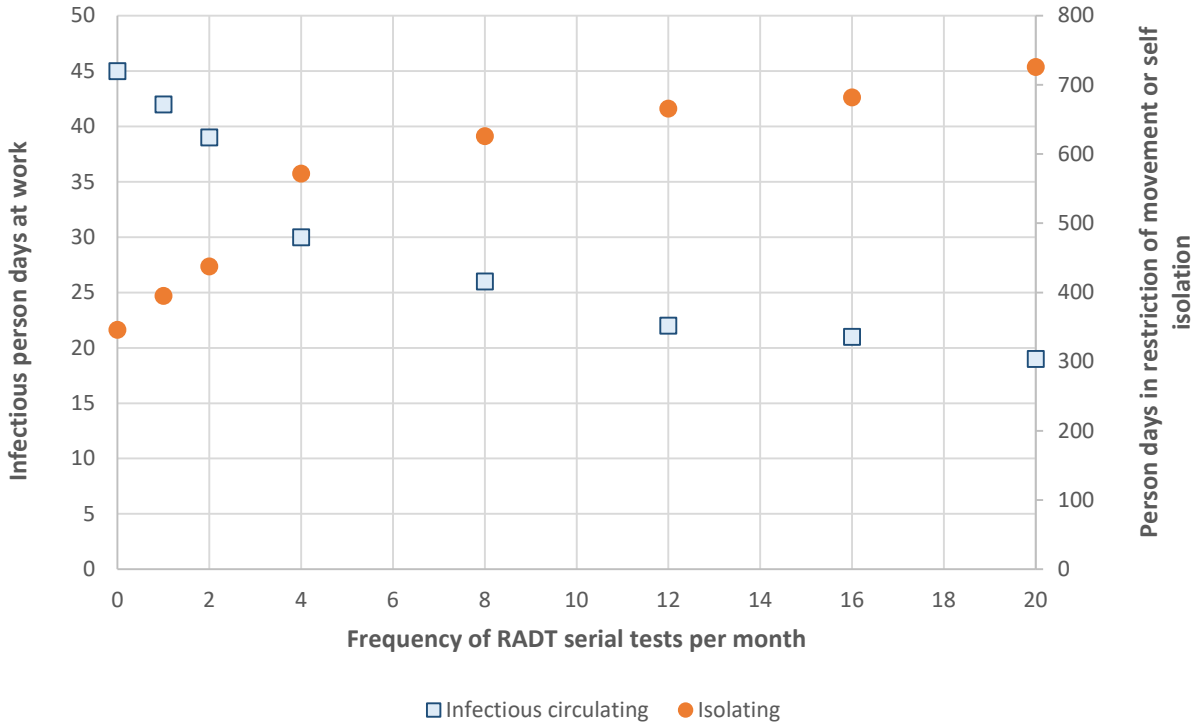


Note: The intersection of the two data series should not be interpreted as an optimal frequency of testing.

Figure 5 outlines the number of infectious person-days versus the number of person-days in self-isolation or restriction of movements, across the number of RADTs completed. It should be noted that an increase in the person-days in self-isolation and restriction of movements will be a function of detected cases and close contacts, but also of those awaiting confirmatory RT-PCR from a positive RADT who will subsequently be categorised as false positives. As shown, a convergence is highlighted for weekly RADT. A widening gap is seen beyond this frequency of testing with a plateauing reduction in infectious person-days. As with Figure 4, the

two variables plotted are not equivalent outcomes, and therefore the intersection of the data series should not be interpreted as indicative of an optimal frequency of testing.

Figure 5. Infectious person-days versus person-days in self-isolation or restriction of movements by frequency of RADT testing (per hypothetical 250 worker cohort in a month)



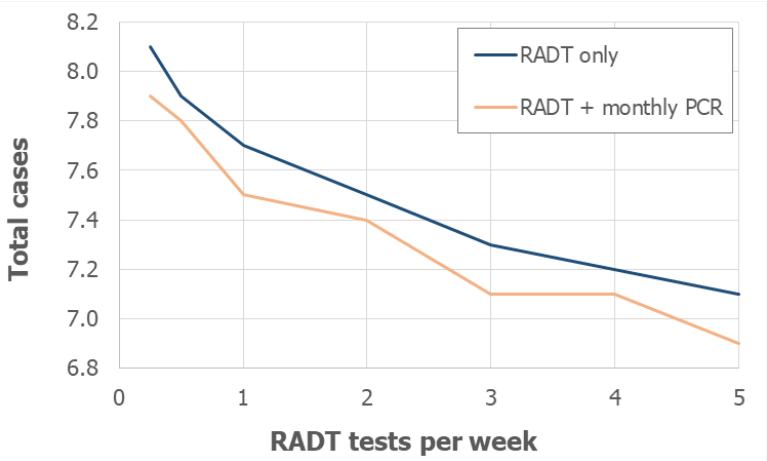
Note: The intersection of the two data series should not be interpreted as an optimal frequency of testing.

RADT-based serial testing in combination with monthly RT-PCR

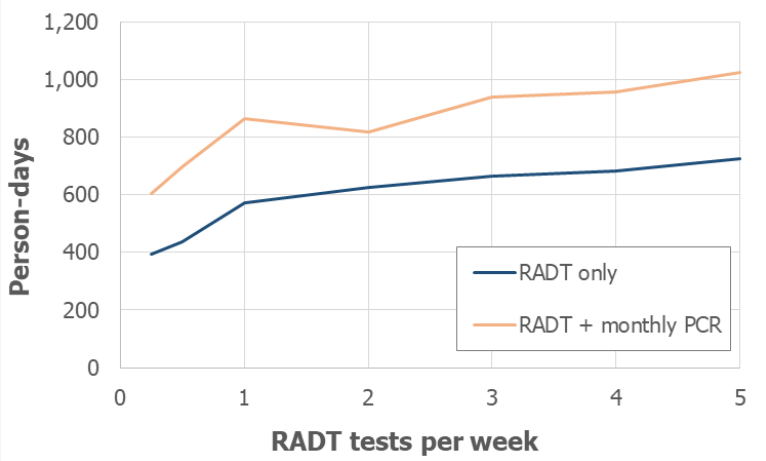
Results for scenarios considering RADT-based serial testing when used in combination with monthly RT-PCR testing are presented in Appendix 1. Figure 6 presents the impact of varying frequencies of RADT-based testing when used in isolation and when combined with the current strategy of monthly RT-PCR testing. As shown, the impact of the two different approaches is relatively similar; however, use of RADT-based serial testing in combination with monthly RT-PCR is associated with increased cost. In this light, given the assumptions within this report (that is, same uptake of RADT and RT-PCR), the addition of RADT-based testing to the current strategy, would not appear to add substantial benefit over and above RADT-based testing alone.

Figure 6. RADT-based testing in isolation and when used in combination with monthly RT-PCR based testing

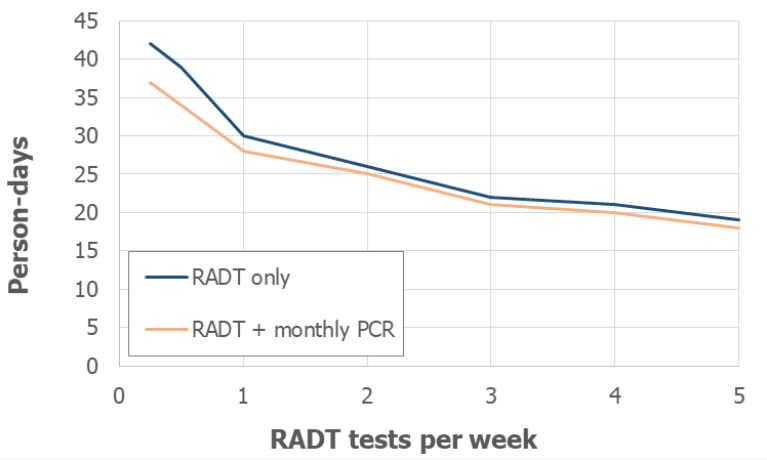
Total cases per month



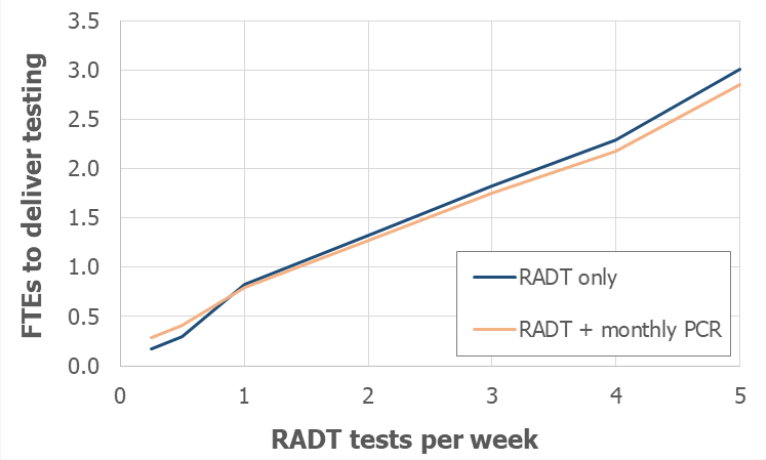
Person days in self-isolation or restriction of movement



Infectious person-days in the community



Full-time equivalents needed to deliver testing



Sensitivity analysis

A series of sensitivity analyses were carried out to explore the impact of structural and certain parameter assumptions in the model. Example results are shown for the existing approach of monthly RT-PCR serial testing (Table 13) and for the incremental comparison of weekly RADT and monthly RT-PCR (Table 14). Varying the background incidence rate and a lower estimate for workplace close contacts both had a marked effect on the total number of infected individuals.

In terms of the comparison of weekly RADT with monthly RT-PCR, the direction of the incremental difference was unchanged in almost all cases, but the magnitude of the difference could vary substantially, particularly for person-days in self-isolation or restriction of movement. Weekly RADT generally resulted in fewer person days in self-isolation or restriction of movement. However, in an analysis with a high background incidence, weekly RADT was associated with more person-days in self-isolation or restriction of movement than monthly RT-PCR.

Overall the different sensitivity analyses had a limited impact on the ordering of the scenarios for each outcome.

The use of high frequency RADTs for serial testing rather than RT-PCR may have reduced acceptability for workers. To test the extent to which a lower uptake could impact on the outcomes for a RADT serial testing programme, a series of uptake values were modelled. For the number of person-days in self-isolation, the uptake of once a week RADT would have to be 90% or higher to generate the same number of person-days as monthly RT-PCR with an uptake of 75% (Figure 7). In terms of infectious person-days circulating, even with an uptake of 45% for once a week RADT there would be fewer infectious person-days than for monthly RT-PCR with an uptake of 75% (Figure 8).

Figure 7. Person-days in self-isolation versus uptake of once a week RADT testing (per hypothetical 250 worker cohort in a month)

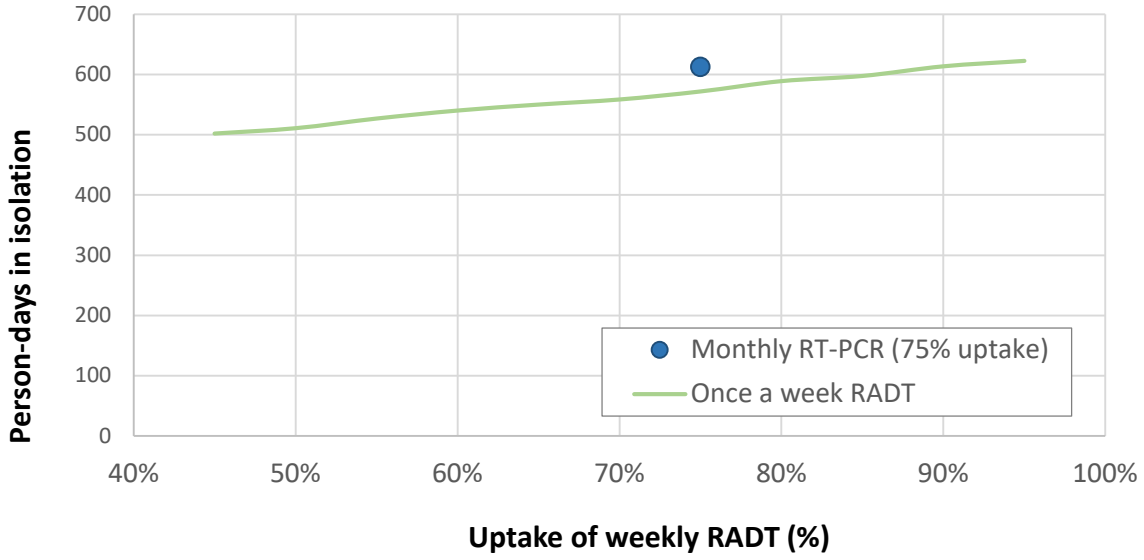


Figure 8. Infectious person-days circulating versus uptake of once a week RADT testing (per hypothetical 250 worker cohort in a month)

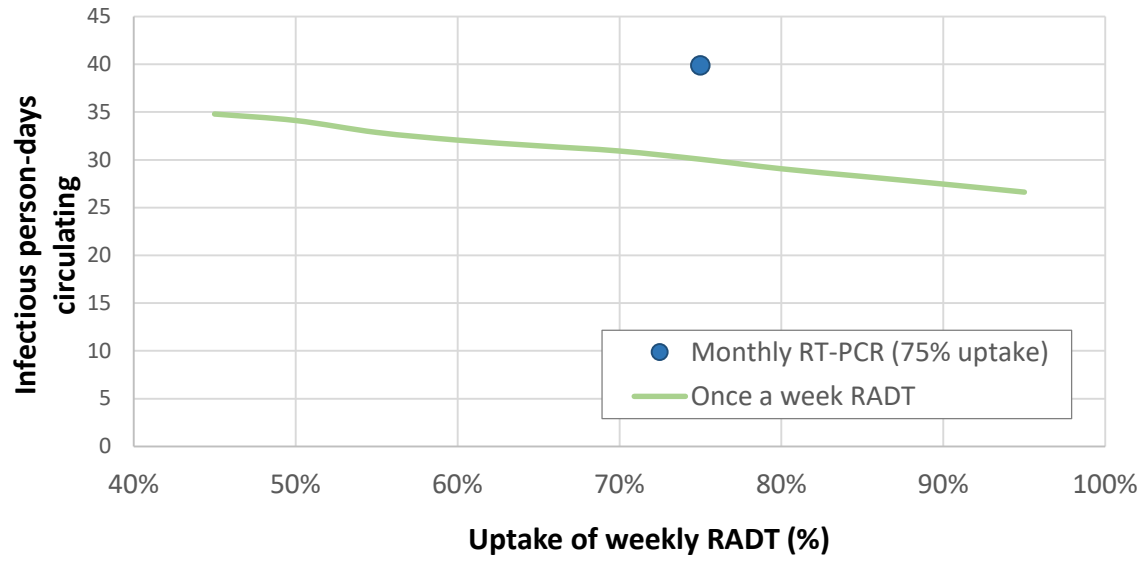


Table 13. Monthly RT-PCR: impact of sensitivity analyses

Sensitivity analysis	Total infected individuals		Person days in self-isolation or restriction of movement		Infectious person-days in the workplace		Full-time equivalent testing staff	
	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI
Main analysis	8.0	[2.0 to 15.5]	613	[120 to 1175]	40	[7 to 85]	0.16	[0.11 to 0.23]
Low background incidence (0.0003)	3.9	[0.5 to 9.5]	429	[66 to 888]	20	[0 to 54]	0.15	[0.11 to 0.21]
High background incidence (0.0012)	14.9	[6.0 to 25.0]	936	[337 to 1,638]	72	[26 to 131]	0.19	[0.13 to 0.26]
Zero-inflated incidence¥	8.1	[1.0 to 18.0]	591	[96 to 1,256]	40	[3 to 97]	0.16	[0.11 to 0.24]
Increased proportion symptomatic cases seek testing (75%)	7.9	[2.0 to 15.5]	729	[227 to 1,310]	33	[7 to 73]	0.17	[0.12 to 0.24]
Lower estimated number of close contacts in work	5.8	[1.5 to 11.5]	576	[105 to 1,104]	30	[6 to 64]	0.16	[0.11 to 0.22]
ROM delay until index case confirmed	7.8	[2.0 to 15.0]	587	[150 to 1,139]	38	[8 to 82]	0.16	[0.11 to 0.23]
Lower percentage of work close contacts infected (0.10)	7.0	[1.5 to 14.0]	605	[170 to 1,151]	36	[6 to 80]	0.17	[0.12 to 0.23]
Low uptake (65%)	7.9	[2.0 to 15.0]	583	[158 to 1,122]	39	[8 to 87]	0.15	[0.10 to 0.21]
High uptake (85%)	7.8	[2.0 to 15.0]	656	[197 to 1,185]	37	[8 to 83]	0.18	[0.13 to 0.25]
Full coverage of staff	7.7	[2.0 to 15.5]	729	[214 to 1,315]	37	[6 to 80]	0.23	[0.17 to 0.31]
High specificity for RT-PCR (99.5%)	8.0	[2.0 to 16.0]	517	[84 to 1,055]	40	[6 to 86]	0.16	[0.11 to 0.21]
High household secondary attack rate (35%)	8.5	[2.0 to 17.0]	647	[138 to 1,259]	42	[8 to 91]	0.17	[0.11 to 0.23]
All cases are infectious	8.2	[2.0 to 16.5]	623	[126 to 1,185]	41	[7 to 89]	0.16	[0.11 to 0.23]
High proportion of cases are not infectious^	7.7	[2.0 to 15.5]	602	[120 to 1,177]	39	[7 to 83]	0.16	[0.11 to 0.23]

¥ The main analysis assumes a binomial distribution of sporadic cases over the time horizon. An alternative of a zero inflated binomial was used to reflect that sporadic cases may cluster.

^ Assuming 10% of symptomatic cases and 21% of asymptomatic cases are not infectious at any point.

Table 14. Weekly RADT relative to monthly RT-PCR: impact of sensitivity analyses

Sensitivity analysis	Total infected individuals		Person days in self-isolation or restriction of movement		Infectious person-days in the workplace		Full-time equivalent testing staff	
	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI
Main analysis	-0.3	[-4.5 to 3.5]	-41	[-515 to 413]	-10	[-41 to 14]	0.66	[0.48 to 0.88]
Low background incidence (0.0003)	-0.1	[-3.0 to 3.0]	-123	[-538 to 302]	-5	[-28 to 12]	0.68	[0.51 to 0.89]
High background incidence (0.0012)	-0.6	[-5.5 to 4.5]	77	[-470 to 666]	-18	[-59 to 15]	0.63	[0.46 to 0.82]
Zero-inflated incidence[¥]	-0.3	[-4.5 to 3.5]	-25	[-461 to 447]	-10	[-46 to 11]	0.67	[0.5 to 0.87]
Increased proportion symptom cases seek testing (75%)	-0.2	[-4.0 to 3.5]	-110	[-576 to 351]	-6	[-33 to 15]	0.66	[0.47 to 0.87]
Lower estimated number of close contacts in work	-0.1	[-3.0 to 2.5]	-88	[-554 to 358]	-6	[-30 to 12]	0.67	[0.49 to 0.88]
ROM delay until index case confirmed	-0.2	[-4.0 to 3.5]	-22	[-529 to 429]	-10	[-40 to 16]	0.68	[0.51 to 0.89]
Lower percentage of work close contacts infected (0.10)	-0.2	[-3.0 to 3.0]	-42	[-513 to 469]	-8	[-37 to 13]	0.67	[0.48 to 0.87]
Low uptake (65%)	-0.3	[-4.5 to 3.0]	-37	[-476 to 416]	-9	[-40 to 14]	0.59	[0.42 to 0.77]
High uptake (85%)	-0.4	[-4.5 to 3.0]	-60	[-552 to 445]	-10	[-42 to 10]	0.76	[0.57 to 0.98]
Full coverage of staff	-0.1	[-4.0 to 3.5]	-160	[-713 to 336]	-7	[-37 to 16]	0.60	[0.44 to 0.79]
High specificity for RT-PCR (99.5%)	-0.3	[-4.0 to 3.5]	44	[-348 to 483]	-10	[-41 to 13]	0.67	[0.49 to 0.89]
High household secondary attack rate (35%)	-0.4	[-5.0 to 3.5]	-32	[-505 to 465]	-10	[-44 to 15]	0.66	[0.47 to 0.88]
All cases are infectious	-0.3	[-4.5 to 4.0]	-38	[-498 to 439]	-10	[-42 to 15]	0.66	[0.48 to 0.88]
High proportion of cases are not infectious[^]	-0.2	[-4.0 to 3.5]	-40	[-533 to 413]	-9	[-40 to 14]	0.66	[0.48 to 0.88]

[¥] The main analysis assumes a binomial distribution of sporadic cases over the time horizon. An alternative of a zero inflated binomial was used to reflect that sporadic cases may cluster.

[^] Assuming 10% of symptomatic cases and 21% of asymptomatic cases are not infectious at any point.

Discussion

This analysis aimed to model the potential impact on transmission risk and resource requirements for different RADT-based serial testing scenarios in meat processing plants in Ireland. The estimates presented within this analysis highlight that increases in the frequency of RADT-based testing of workers in meat processing plants, with positives tests confirmed by RT-PCR, are associated with increases in the detection of cases and reductions in potential infectious person-days in circulation. At testing frequencies of up to three times per week, the overall cost of RADT-based testing is comparable to or lower than the current practice of monthly RT-PCR testing, while the number of person-days in self-isolation or restriction of movements is also lower or largely comparable up to this point. However, increasing staffing requirements are noted as RADT frequency increases (above a monthly frequency).

Overall the results of the model indicate that, relative to the current strategy of monthly RT-PCR testing, scenarios which involve RADT testing at a frequency of once or twice weekly appear to offer the most benefit in terms of increased case detection and reduced infectious-person days at work, while potentially reducing the overall cost of testing. Fortnightly RADT testing may offer comparable results to current practice in terms of case detection and infectious person-days circulating at an overall reduced cost. However, while most of the RADT serial testing strategies may be delivered at a lower cost relative to monthly RT-PCR serial testing, they have substantially increased staff resource requirements which may create logistical challenges. Given the assumptions within this report, the addition of RADT-based testing to the current strategy (that is, use of RADT-based testing in combination with monthly RT-PCR testing), does not appear to add substantive benefit over and above RADT-based testing in isolation; however, it is associated with higher costs.

The analyses presented here have made no assumptions regarding on whom the cost of serial testing should fall. In the current model of care, the costs and resources to provide monthly RT-PCR serial testing fall on the HSE Test and Trace Programme. With respect to serial testing based on RADT, costs could be split between the HSE and the meat processing industry, that is, the cost of any RT-PCR testing (testing symptomatic individuals and confirmatory testing subsequent to a positive RADT) would accrue to the HSE; costs associated with supervising self-samples and processing and reporting the RADT would accrue to the meat processing plant industry; procurement costs for the RADT test kits could also accrue to the industry, or these kits could be provided to the industry by the HSE. The cost and provision of competency based training for staff to conduct the testing is a further factor to be taken into account. Based on the ongoing roll-out of RADT-based serial testing, the HSE provides the test kits while the meat processing plants

manage the sampling, testing and reporting processes themselves as well as maintaining quality standards in testing.

Consideration could be given to an adaptive approach whereby the frequency of RADT testing is increased at times of high local incidence of COVID-19. This could lower the testing burden and rate of false positives at times when the pre-test probability is low. When local incidence is high, a more frequent schedule of testing would help ensure that the extent of outbreaks is minimised. However, adapting the schedule in this manner would further complicate the logistical challenges associated with a high frequency testing approach.

It should be reiterated that all positive RADTs were assumed to have a follow-on confirmatory RT-PCR test, which is currently the standard diagnostic test. As a number of these positive cases are noted to be reconciled as false positives, the productivity loss associated with self-isolation and restriction of movements while awaiting these confirmatory results should be considered. Therefore, the increasing number of person-days in isolation or restriction of movements with increasing RADT frequency should be considered as a function of both appropriate and inappropriate restriction which may have important implications for productivity loss and or loss of income which have not been considered within this analysis. The implications of a positive test result can create incentives and disincentives for participation in serial testing. In the analysis presented, it was assumed that those who avail of testing will also voluntarily follow the public health guidance following a positive test result and will undertake the subsequent RT-PCR test. It should be further emphasised that the use of a confirmatory RT-PCR test for positive RADT results is an important assumption within the model. In the absence of this assumption, a growing number of false positive tests are observed with increasing frequency of RADT testing, and hence would result in a greater number of days for the worker and close contacts unnecessarily spent in self-isolation and or restriction of movements.

The overall acceptability of such testing regimens for all relevant stakeholders including the worker, employer, and the wider public health concern has not been accounted for within this analysis. This may be particularly relevant in terms of the increased testing frequency seen with the scenarios outlined. Although the use of RADT-based on supervised self-swabbing of mid-turbinate nasal swabs involves less invasive self-swabbing compared to the current provider-collected combined oropharyngeal nasopharyngeal specimen, the augmented frequency may impact on overall uptake of testing, hence potentially negating the benefits outlined. A further consideration is the need for on-site trained individuals to complete the RADT processes.[15] Although the total costs associated with the RADT scenarios outlined were lower or comparable to the current practice of monthly RT-PCR up to the point of twice weekly RADT, the number of FTE staff required to complete the testing process was higher for all RADT-based scenarios. This will be further reflected in the

organisational and logistical requirements of implementing such a testing regimen with an increasing frequency of testing. Additionally, the logistics of capturing all workers at multiple time points in a month when considering shift changes and work schedules is likely to be challenging. If the sampling, processing and reporting of RADT-based testing is undertaken by the meat processing plants, as has been the case in the initial roll-out, then the logistics of how such testing would be undertaken would be organised at the level of the plant.

Further considerations with implementing a serial testing programme of this nature include the operational oversight and clinical governance. Issues such as procurement, audit trails of test distribution and usage, and the requirement for a quality management system require careful consideration alongside the designation of responsibility for such requirements. Key aspects of the quality management system include the need for internal and external quality control, including requirements for batch acceptance tests to confirm the suitability of new batches of kits for use. Additionally, in terms of clinical governance, appropriate processes and procedures would need to be implemented to ensure the appropriate competency-based training of staff, supervision of testing, follow up of positive tests for confirmatory RT-PCR, linkage to IT systems to ensure timely notification and informing of positive test results, the tracing and testing of close contacts, and the reporting to and engagement with existing public health programmes to ensure such strategies complement and support existing measures rather than replace or diverge. Of note, the Department of Agriculture, Food and the Marine have been working to support the meat processing plants in the implementation of RADT-based testing.[35] High adherence, acceptability, and benefit in relation to rapid case identification and isolation were observed during the validation studies; however, transitional implementation from HSE based to employer based programmes have been associated with limitations overall. Logistical and practical implications of rolling out such regimens have been noted to be challenging, with strategies required to reduce administrative burden, while maintaining quality and assurance of sampling, testing and tracing processes.

As noted, meat processing plants nationally and internationally have experienced outbreaks of SARS-CoV-2 and this industry is associated with a considerable burden of infection overall.[4-6] Parameter data to enable appropriate modelling of the potential impact of RADT-based serial testing was informed by national surveillance data from this setting, as well as data from a RADT-based validation study conducted in workers of meat processing plants enrolled in the monthly RT-PCR based serial testing programme. However, the national surveillance data for meat processing plants reflect the impact of the suite of IPC measures adopted in this setting. Therefore the parameter data informing the model are specific to the meat processing plants and should not be considered transferrable to other settings. The

potential impact of such testing in other settings would need to be supported by validation work and epidemiological surveillance specific to the setting of interest, as recommended by the ECDC.[14] It should be further emphasised that the results presented within this analysis reflect the sensitivity and specificity of a specific RADT validated in workers in the meat processing industry in Ireland enrolled in the monthly RT-PCR based serial testing programme.[27] These estimates may not be applicable to other RADTs. A report published 1 April 2021 by the COVID-19 Rapid Testing Group,[36] established by the Minister for Health, outlines a number of recommendations for rapid testing considering four terms of reference: recommendations on settings for use, settings for prioritisation, consideration of use in schools, and implementation of recommended testing. The recommendations of the group, by a majority, include that rapid tests, such as lateral flow antigen tests and loop-mediated isothermal amplification tests, should complement existing national HSE Public Health RT-PCR testing programmes, preferably through the use of self-administered sampling (nasal or saliva). Individuals with COVID-19 symptoms should continue to be tested within the existing public health testing framework. The recommendations further highlight that consideration should be given to the establishment of a number of testing pilots and or feasibility studies by different Government Departments, Agencies and stakeholder groups across a broad spectrum of populations.

There are a number of important ethical factors when considering such surveillance programmes including autonomy, fairness and privacy.[37, 38] The balance of benefit and burden when considering the individual worker, colleagues, the employer and the wider population well-being should be considered. The protection of the autonomy of the worker, and the assurance of informed consent, must be taken into account, their decision to partake or not partake, and the implications of such decisions in terms of their overall rights to ensure fairness. The ethical principle of privacy is a significant consideration, the individual has a right to privacy and confidentiality with respect to their health information (for example disclosure of a positive test result to their employer); however, in extenuating circumstances within a pandemic this right may be temporarily constrained in the interest of the protection of the broader population health.

Limitations

Context of data

The model developed for this study is fully probabilistic, reflecting the uncertainty in the true values of the various included parameters. While variability across patients is modelled, there is an averaging effect in aggregating results to a group level. The data are a mixture of international and Irish-specific estimates and reflect what is known at this point in time. It is evident that there have been quite substantial shifts

over time in the demographic characteristics of those infected with SARS-CoV-2 in Ireland. It was assumed that the disease parameters used in the model are appropriate for the demographic group represented by meat processing plant workers.

The data on test performance were derived from validation studies that took place in a particular context. It is unclear that similar diagnostic test performance would be achieved with a serial testing programme that used unsupervised self-swabbing and or self-testing, for example. The diagnostic test accuracy achieved in the RADT validation studies was lower than what was reported by the manufacturers, highlighting the challenges of managing diagnostic testing in real-world settings. Periodic verification studies as part of an ongoing system of quality assurance would be needed to confirm the performance of the tests.

Data quality

The model included a variety of parameters with values obtained from a wide range of heterogeneous sources. Some were derived from observational studies which were not always designed to estimate the parameter of interest.

It is also important to note that the available data describes the course of COVID-19 in a wide range of settings and population groups, not all of which may be applicable to an Irish setting. While characteristics of the infection itself are likely to be similar across populations, those aspects that are affected by human behaviour could vary immensely, for example close contacts and secondary attack rates in different settings. The model presented here used uncertainty around parameter estimates to explore uncertainty in the relative effects of the different scenarios modelled.

Background incidence

The model required an estimate of the background incidence that gives rise to sporadic cases that act as the vector to introduce SARS-CoV-2 into the workplace. A constant value was used in the model as a simplification. The background incidence used in the model was calibrated based on a comparison of the modelled positivity rate and the true positivity rate for the monthly RT-PCR serial testing carried out to date. In reality, incidence is constantly changing and reflects the degree of community transmission occurring. Rather than varying the background incidence in the model, the impact of using alternate values was explored in a sensitivity analysis. When the background incidence is high, there are more cases to be detected. For RADT scenarios, this means a higher number of confirmatory RT-PCR tests and higher associated costs.

Furthermore, the current vaccination roll out will likely impact on community incidence rates which will have implications for the estimates presented within this report.

Infectiousness

An important consideration in the spread of COVID-19 is the period and magnitude of infectiousness in an index case. The estimates of duration of infectiousness implicitly acknowledge that viral load declines over time to the extent that an individual may no longer be infectious, but can still test positive with RT-PCR. It is plausible that peak infectiousness may occur early in the infection, as demonstrated by the proportion of onward infections that occur prior to symptom onset.[39] However, it is worth considering that the propensity to infect and the opportunity to infect are distinct, and that symptomatic cases will typically self-isolate, reducing the opportunity to transmit disease. The reported data likely reflect the fact that both propensity and opportunity to infect decreases over time.

Infectiousness and viral load are particularly important when considering the diagnostic test accuracy of RADTs. The test performance is poorer than for RT-PCR, especially when considering asymptomatic cases. This can reflect a lower potential to transmit disease. The available data suggest lower secondary attack rates in relation to asymptomatic and pre-symptomatic cases.[28] However, it should be noted that asymptomatic and pre-symptomatic people are less likely to be restricting their movement and contacts, so while the secondary attack rate may be lower, it might apply to a larger number of close contacts. Thus the potential to infect is lower by way of a lower viral load, but it may be partly compensated for by greater exposure. To account for the fact that some individuals may not become infectious, data on the proportion of cases with Ct less than 30 was used as a proxy for infectiousness. Assuming that some people may have had higher viral loads either before or after testing, it was conservatively assumed that, on average, half of the people with low viral loads (i.e., Ct values above 30) do not become infectious. That is, half of people with low viral loads do not develop a sufficient viral load to infect any of their close contacts. The assumption was tested in a sensitivity analysis by making all cases infectious, and it had a negligible impact of the results and did not change the interpretation of the findings.

Close contact data

Data were accessed on the close contacts of cases linked to food and meat processing plants.[40, 41] Of the 3,182 cases identified in CIDR, 2,307 (72.5%) could be linked to contact tracing data. Contact types can be classified into one of a number of categories. For this analysis, the interest was in close contacts within a person's household and in the workplace. One issue is that many close contacts are uncategorised in the data. Of 8,167 close contacts, 4,061 were uncategorised. Two approaches were used to redistribute uncategorised contacts: in proportion to frequency that the other categories appeared, and allocation of all to the workplace setting. Re-allocating uncategorised cases proportionately resulted in an average of

0.6 workplace close contacts. With a secondary attack rate of 10% to 20%, the average index case will infect 0.06 to 0.12 cases in the workplace, which would render outbreaks self-limiting. Re-allocating uncategorised cases as workplace resulted in an average of 2.1 workplace close contacts, leading to an average of 0.2 to 0.4 cases generated by the index case. This higher figure for close contacts in the workplace was used in the main analysis on the grounds that food and meat processing plants have been associated with numerous outbreaks and that transmission occurs between index cases and close contacts. The lower number of close contacts was tested in a sensitivity analysis.

Uptake of serial testing and adherence to self-isolation

The context for serial testing is primarily the identification of asymptomatic or pre-symptomatic cases. Workers are therefore requested to engage in testing to reduce the risk of transmission. When a worker is identified as having a SARS-CoV-2 infection, there may be implications in terms of loss of earnings. Many may also find the process of swabbing uncomfortable. Therefore, there may be resistance to participating in serial testing. From the perspective of modelling, the issue is whether those more likely to decline testing are also more likely to be infected. There are no data available to determine whether that might be the case. It should be noted that even if some infected individuals do not engage with serial testing, the process can still result in the early detection of secondary infections and thereby limit the extent of an outbreak.

For this report, it was assumed that all confirmed positives will self-isolate or at least stay away from the workplace setting until the period of self-isolation is completed. Whether this occurs in reality may depend on the extent to which the employer is notified of individual cases identified through serial testing, and the supports in place to mitigate the effects of loss of earnings. It is noted however that recent UK based data for the general population suggests a high level of adherence to self-isolation following a positive test (>94% fully adherent) and following identification as a close contact (approximately 90% fully adherent).[42, 43]

Symptomatic cases seeking testing outside of serial testing

There are a wide range of symptoms associated with COVID-19 aside from the well-recognised symptoms (for example, fever or breathlessness). Symptomatic individuals include those who have minimal or mild symptoms, so that not all individuals that have symptoms will necessarily identify as such and continue to present for work. For the purposes of the model it was assumed that a proportion of individuals would seek and be referred for testing through the existing national Test and Trace programme on becoming symptomatic. It was assumed that 50% of symptomatic individuals would go for testing. This assumption was based on the fact that the proportion identifying as symptomatic in this setting was lower than for

individuals generally in outbreak settings. In the CIDR database that records all COVID-19 notifications in Ireland, symptom status at the time of notification is recorded. For those not linked to an outbreak, 88.2% of 20 to 59 year olds are recorded as symptomatic. For those linked to an outbreak other than in a meat or food processing plant, the figure is 82.5%, while for those in a meat or food processing plant it is 64.0%. It is possible that the lower proportion symptomatic reflects earlier detection due to serial testing, and that a substantial proportion of those listed as asymptomatic would go on to develop symptoms. However, it may also reflect under-reporting of symptoms which could reflect a desire not to be identified as having SARS-CoV-2 or to be able to return to work as soon as possible. It should be noted that, based on data from validation of RADTs for serial testing, the rate of positivity in symptomatic individuals was between 10% and 12%, suggesting that symptoms may be a poor marker of infection.

Heterogeneity in meat processing plants

The model does not take into account the potential heterogeneity within and between meat processing plants. Meat processing plants vary in occupancy levels and operational environments dependent on the activities undertaken and product types. In addition, individual meat plants are compartmentalised for reasons of animal welfare and food hygiene. In turn, this denotes that the risk within and between plants is heterogeneous. In particular, poorer air circulation and higher occupancy levels in certain areas of certain plants (for example, meat cutting rooms or boning halls) may present with increased risk of transmission.

Correlation between variables

As the various parameter estimates were each derived independently, we have assumed that they are not correlated. That is, that an individual with a long latent period may also have a long pre-symptomatic infectious period. Certain correlations could be important, such as if asymptomatic cases had a longer infectious period, as this would imply that in the absence of being test-detected or adhering to restricted movements that they could infect many individuals. In terms of future research and to aid understanding of individuals described as superspreaders, it would be useful for studies to consider the extent to which infection characteristics are correlated.

Calibration of model

The model was developed to simulate the occurrence of outbreaks in meat processing plants. It was possible to compare the performance of the model against observed data for the extent of outbreaks and the rate of positivity in the historical rounds of monthly RT-PCR serial testing. Based on calibration, it was found that the number of close contacts in the workplace setting was likely to be higher than

reported. It was also found that the secondary attack rate was likely to be higher than for typical workplace settings.

The model structure reflected a meat processing plant as a homogenous unit and the likelihood of transmission being a function of close contacts, infectiousness and being present at work. The reality is that the environmental conditions in certain areas in the plant facilitate transmission between individuals that may not formally be considered close contacts. A model that incorporates that complexity of interaction would require substantially more detail to develop, and may have to separately model compartments within a plant while allowing for interaction between individuals in different areas of the plant possibly to reflect close contacts through co-habitation. Such an approach may improve accuracy in the prediction of outbreaks but be less generalisable across plants. An alternative would be to artificially inflate the number of close contacts for a subgroup of plant workers to reflect the transmission risk associated with, for example, working in the boning hall.

Modelled scenarios

A selected group of potential testing scenarios were modelled in this report. Other frequencies of testing may be feasible, or other approaches that might better facilitate the logistics of testing staff travelling to a large number of locations around the country (for example more frequent testing on alternate weeks).

Variants of concern

The data used in the model largely reflect historical data prior to the emergence and dominance of the B.1.1.7 variant of concern. This variant is considered to have higher transmissibility than other circulating strains and hence may influence the estimates presented overall if analysed in isolation; however the separation of all parameter data based on the timeline for the emergence and dominance of this strain was not possible.

Conclusions

Given recent RADT validation work performed in meat processing plants in Ireland, this analysis modelled the potential impact on transmission risk and resource requirements associated with implementing various frequencies of RADT-based serial testing (supplemented by confirmatory RT-PCR testing for positive results). The estimates presented within this analysis highlight that increases in the frequency of RADT-based testing are associated with increases in the detection of cases and reductions in potential infectious person-days in circulation. However, the increasing frequency was associated with an increasing overall cost, staff requirements, and time spent in self-isolation or restriction of movements. Based on the assumptions within this report, the addition of RADT-based testing to the current strategy (that

is, use in combination with monthly RT-PCR testing), does not appear to add substantive benefit over and above RADT-based testing in isolation.

Of the scenarios assessed, on balance, the use of RADT at a frequency of once or twice a week appears to offer the largest benefits in terms of a potentially increased detection of cases, reduction in infectious person-days circulating, and a reduced overall cost relative to the current practice of monthly RT-PCR testing. Fortnightly RADT based testing may offer comparable rates of detection, and hence infectious-person days in the workplace, at a reduced cost compared to current practice. While total cost was estimated to be lower for a number of the RADT scenarios, the staffing requirements for the implementation of testing processes on site were substantially higher when considering all RADT scenarios compared to current practice.

A number of important assumptions have been included within these analyses which should be considered when interpreting the estimates provided. Additionally, there are a number of important factors which have not been accounted for within this analysis that should be considered within decision-making overall, including the acceptability of any change in testing to all relevant stakeholders, the potential impact on productivity, the training and availability of persons to implement RADT-based regimens, the operational and logistical implementation of such testing regimens, the heterogeneity in meat processing plants, as well as the requirements for operational oversight, clinical governance and quality assurance. Given the specificity of the parameter data to meat processing plants, these estimates are not transferable to other settings.

References

1. European Centre for Disease Control. Overview of the implementation of COVID 19 vaccination strategies and vaccine deployment plans in the EU/EEA 2021 [Available from: https://www.ecdc.europa.eu/sites/default/files/documents/Overview-of-COVID-19-vaccination-strategies-deployment-plans-in-the-EU-EEA.pdf.
2. European Medicines Agency. COVID-19 vaccines 2021 [Available from: https://www.ema.europa.eu/en/human-regulatory/overview/public-health-threats/coronavirus-disease-covid-19/treatments-vaccines/covid-19-vaccines.
3. European Commision. Preparedness for COVID-19 vaccination strategies and vaccine deployment 2020 [updated 15 December 2020. Available from: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2020:0680:FIN.
4. European Centre for Disease Control. COVID-19 clusters and outbreaks in occupational settings in the EU/EEA and the UK 2020 [Available from: https://www.ecdc.europa.eu/sites/default/files/documents/COVID-19-in-occupational-settings.pdf.
5. European Federation of Food Agriculture and Tourism Trade Unions. Covid-19 outbreaks in slaughterhouses and meat processing plants: State of affairs and proposals for policy action at EU level 2020 [Available from: https://effat.org/wp-content/uploads/2020/06/EFFAT-Report-Covid-19-outbreaks-in-slaughterhouses-and-meat-packing-plants-State-of-affairs-and-proposals-for-policy-action-at-EU-level.pdf.
6. Health Information and Quality Authority. Evidence synthesis for groups in vaccine allocation group nine - those aged 18-64 years living or working in crowded conditions 2021 [Available from: awaiting publication
7. House of the Oireachtas. Special Committee on Covid-19 Response debate - Thursday, 13 Aug 2020: Covid-19 The Situation in Meat Processing Plants 2020 [Available from: https://www.oireachtas.ie/en/debates/debate/special_committee_on_covid-19_response/2020-08-13/3/.
8. House of the Oireachtas. Special Committee on Covid-19 Response debate - Friday, 10 Jul 2020 2020 [Available from: https://www.oireachtas.ie/en/debates/debate/special_committee_on_covid-19_response/2020-07-10/3/.
9. Health Information and Quality Authority. Airborne transmission of SARS-CoV-2 via aerosols 2020 [Available from: https://www.hiqa.ie/reports-and-publications/health-technology-assessment/evidence-summary-airborne-transmission-sars.
10. National Outbreak Control Team. Investigation into a Series of Outbreaks of COVID-19 in Meat Processing Plants in Ireland, 2020 2020 [Available from: https://assets.gov.ie/95603/8c23ae9c-9a30-4c01-9ebf-f624f2c99702.pdf.
11. Health Information and Quality Authority. Activities or settings associated with a higher risk of SARS-CoV-2 transmission 2020 [Available from: https://www.hiqa.ie/reports-and-publications/health-technology-assessment/activities-or-settings-associated-higher-risk.
12. Health Protection Surveillence Centre. COVID-19 Outbreaks in Meat Factories in Ireland Outbreak Control Team Interim Guidance on COVID-19 2021 [Available from: https://www.hpsc.ie/a-z/respiratory/coronavirus/novelcoronavirus/guidance/outbreakmanagementguidance/outbreakcontrolinmeatfactories/COVID-19%20Outbreaks%20in%20Meat%20Factories.pdf.

13. Centers for Disease Control and Prevention. Interim Guidance for Antigen Testing for SARS-CoV-2 2020 [Available from: https://www.cdc.gov/coronavirus/2019-ncov/lab/resources/antigen-tests-guidelines.html.
14. European Centre for Disease Prevention and Control. Options for the use of rapid antigen tests for COVID-19 in the EU/EEA and the UK 2020 [Available from: https://www.ecdc.europa.eu/sites/default/files/documents/Options-use-of-rapid-antigen-tests-for-COVID-19_0.pdf.
15. World Health Organization. Antigen-detection in the diagnosis of SARS-CoV-2 infection using rapid immunoassays: Interim guidance 2020 [Available from: https://www.who.int/publications-detail-redirect/antigen-detection-in-the-diagnosis-of-sars-cov-2infection-using-rapid-immunoassays.
16. Health Information and Quality Authority. Rapid health technology assessment (HTA) of alternatives to laboratory-based real-time RT-PCR to diagnose current infection with severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) 2020 [Available from: Awaiting publication
17. Kucirka LM, Lauer SA, Laeyendecker O, Boon D, Lessler J. Variation in false-negative rate of reverse transcriptase polymerase chain reaction–based SARS-CoV-2 tests by time since exposure. Annals of Internal Medicine. 2020.
18. Payne D, Newton D, Evans P, Osman H, Baretto R. Preanalytical issues affecting the diagnosis of COVID-19. Journal of Clinical Pathology. 2020.
19. Woloshin S, Patel N, Kesselheim AS. False Negative Tests for SARS-CoV-2 Infection—Challenges and Implications. New England Journal of Medicine. 2020.
20. Cochrane Database of Systematic Reviews (Dinnes et al). Rapid, point-of-care antigen and molecular-based tests for diagnosis of SARS-CoV-2 infection 2021 [Available from: https://www.cochranelibrary.com/cdsr/doi/10.1002/14651858.CD013705.pub2/full.
21. Walsh KA, Jordan K, Clyne B, Rohde D, Drummond L, Byrne P, et al. SARS-CoV-2 detection, viral load and infectivity over the course of an infection: SARS-CoV-2 detection, viral load and infectivity. Journal of Infection. 2020.
22. Weiss A, Jellingsø M, Sommer MOA. Spatial and temporal dynamics of SARS-CoV-2 in COVID-19 patients: A systematic review and meta-analysis. EBioMedicine. 2020;58:102916.
23. Foundation for Innovative New Diagnostics. Rapid diagnostic tests for covid-19 2020 [Available from: https://www.finddx.org/wp-content/uploads/2020/05/FIND_COVID-19_RDTs_18.05.2020.pdf.
24. Mc Evoy D, McAloon CG, Collins AB, Hunt K, Butler F, Byrne AW, et al. The relative infectiousness of asymptomatic SARS-CoV-2 infected persons compared with symptomatic individuals: A rapid scoping review. medRxiv. 2020.
25. European Centre for Disease Prevention and Control. ECDC rapid assessment of laboratory practices and needs related to COVID-19 2021 [Available from: https://www.ecdc.europa.eu/sites/default/files/documents/covid-19-rapid-assessment-laboratory-practices-needs.pdf.
26. Health Information and Quality Authority. Antigen testing in asymptomatic individuals in community settings 2021 [Available from: https://www.hiqa.ie/reports-and-publications/health-technology-assessment/antigen-testing-asymptomatic-individuals.
27. National Clincial Programme for Pathology. Validation Summary Reports for Rapid Antigen Detection Tests 2021 [
28. Thompson HA, Mousa A, Dighe A, Fu H, Arnedo-Pena A, Barrett P, et al. SARS-CoV-2 setting-specific transmission rates: a systematic review and meta-analysis. Clinical Infectious Diseases. 2021.

29. Buitrago-Garcia DC, Egli-Gany D, Counotte MJ, Hossmann S, Imeri H, Salanti G, et al. Occurrence and transmission potential of asymptomatic and presymptomatic SARS-CoV-2 infections: A living systematic review and meta-analysis. PLOS Medicine 2020.
30. Health Protection Surveillance Centre. Preliminary report of the results of the Study to Investigate COVID-19 Infection in People Living in Ireland (SCOPI): A national seroprevalence study, June-July 2020 2020 [Available from: https://www.hpsc.ie/a-z/respiratory/coronavirus/novelcoronavirus/scopi/SCOPI%20report%20preliminary%20results%20final%20version.pdf.
31. Quilty BJ, Clifford S, Flasche S, Kucharski AJ, Edmunds WJ, Group CC-W. Quarantine and testing strategies in contact tracing for SARS-CoV-2. medRxiv. 2020.
32. Health Information and Quality Authority. Evidence summary for the incubation period of COVID-19, or time to first positive test, in individuals exposed to SARS-CoV-2 2020 [Available from: https://www.hiqa.ie/sites/default/files/2020-11/Evidence-summary-for-the-incubation-period-of-COVID-19.pdf.
33. Health Information and Quality Authority. Evidence summary for duration of infectiousness of SARS-CoV-2 2020 [Available from: https://www.hiqa.ie/reports-and-publications/health-technology-assessment/evidence-summary-duration-infectiousness-sars.
34. Singanayagam A, Patel M, Charlett A, Bernal JL, Saliba V, Ellis J, et al. Duration of infectiousness and correlation with RT-PCR cycle threshold values in cases of COVID-19, England, January to May 2020. Eurosurveillance. 2020;25:2001483.
35. Department of Agriculture Food and the Marine. Personal correspondence: RADT based testing in meat processing plants. 2021.
36. COVID-19 Rapid Testing Group. Safe Sustainable Re-opening: The Role of Rapid SARS-CoV-2 Testing: Report of the COVID-19 Rapid Testing Group 2021 [Available from: https://www.gov.ie/en/publication/f50f0-report-of-the-covid-19-rapid-testing-group/.
37. Department of Health. Ethical Framework for DecisionMaking in a Pandemic 2020 [Available from: https://www.gov.ie/en/publication/dbf3fb-ethical-framework-for-decision-making-in-a-pandemic/.
38. World Health Organization. WHO Guidelines on Ethical Issues in Public Health Surveillance 2017 [Available from: https://www.who.int/ethics/publications/public-health-surveillance/en/.
39. Casey M, Griffin J, McAloon CG, Byrne AW, Madden JM, McEvoy D, et al. Estimating pre-symptomatic transmission of COVID-19: a secondary analysis using published data. medRxiv. 2020.
40. Health Protection Surveillance Centre. COVID-19 Contact Management Programme (CMP) Information for close contacts of a confirmed case of COVID-19 2020 [Available from: https://www.hpsc.ie/a-z/respiratory/coronavirus/novelcoronavirus/factsheetsandresources/2.%20Information%20for%20Close%20Contacts%20of%20a%20confirmed%20case%20of%20COVID-19.pdf.
41. Health Protection Surveillance Centre. Data drawn from: Computerised Infectious Disease Reporting System 2021 [
42. Office for National Statistics. Coronavirus and self-isolation after being in contact with a positive case in England: 1 March to 6 March 2021 2021 [Available from: https://www.ons.gov.uk/peoplepopulationandcommunity/healthandsocialcare/conditionsanddiseases/bulletins/coronavirusandselfisolationafterbeingincontactwithapositivecaseinengland/1marchto6march2021.
43. Office for National Statistics. Coronavirus and self-isolation after testing positive in England: 8 March to 13 March 2021 2021 [Available from:

https://www.ons.gov.uk/peoplepopulationandcommunity/healthandsocialcare/healthandwellbeing/bulletins/coronavirusandselfisolationaftertestingpositiveinengland/8to13march2021.

Appendix 1 - Supplementary results for scenarios considering RADT serial testing used in combination with monthly RT-PCR testing

Table 1. Total number of expected cases (per hypothetical 250 worker cohort in a month)

Scenario	Total		Incremental (relative to comparator)	
	Mean	95% CI	Mean	95% CI
1 (comparator): monthly RT-PCR	8.0	[2 to 15.5]	-	-
2: no serial testing	8.2	[2 to 16]	0.2	[-3.5 to 4]
10: monthly RADT + PCR	7.9	[2 to 15.5]	-0.1	[-4 to 3.5]
11: fortnightly RADT + PCR	7.8	[1.5 to 15]	-0.2	[-4.5 to 3.5]
12: weekly RADT + PCR	7.5	[1.5 to 15]	-0.5	[-5 to 3]
13: twice a week RADT + PCR	7.4	[1.5 to 15.5]	-0.5	[-4.5 to 3]
14: three times a week RADT + PCR	7.1	[1.5 to 14.5]	-0.8	[-5.5 to 3]
15: four times a week RADT + PCR	7.1	[1.5 to 14]	-0.9	[-5.5 to 3]
16: five times a week RADT + PCR	6.9	[1.5 to 13.5]	-1	[-5.5 to 3]

*Total number of expected cases includes those detected and not detected through testing

Table 2. Total infectious person-days (per hypothetical 250 worker cohort in a month)

Scenario	Total		Incremental (relative to comparator)	
	Mean	95% CI	Mean	95% CI
1 (comparator): monthly RT-PCR	40	[7 to 85]	-	-
2: no serial testing	45	[8 to 100]	5	[-20 to 35]
10: monthly RADT + PCR	37	[6 to 79]	-3	[-33 to 22]
11: fortnightly RADT + PCR	34	[6 to 74]	-6	[-38 to 19]
12: weekly RADT + PCR	28	[5 to 62]	-12	[-44 to 10]
13: twice a week RADT + PCR	25	[5 to 54]	-15	[-46 to 4]
14: three times a week RADT + PCR	21	[3 to 46]	-18	[-54 to 7]
15: four times a week RADT + PCR	20	[4 to 46]	-20	[-55 to 5]
16: five times a week RADT + PCR	18	[2 to 42]	-21	[-58 to 3]

Table 3. Total number of true positive cases detected and total number of false positives (per hypothetical 250 worker cohort in a month)

Scenario	Total number of true positive cases detected		Incremental* number of true positive cases detected		Total number of false positives		Incremental* number of false positives	
	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI
1 (comparator): monthly RT-PCR	2.1	[0 to 6]	-	-	1.8	[0 to 5]	-	-
2: no serial testing	1.4	[0 to 4.5]	-0.7	[-3.5 to 2]	0.3	[0 to 1.5]	-1.5	[-4.5 to 0]
10: monthly RADT + PCR	2.7	[0 to 7]	0.6	[-2.5 to 4]	1.8	[0 to 5]	0.1	[-3 to 3]
11: fortnightly RADT + PCR	2.8	[0 to 7]	0.8	[-2.5 to 4]	1.8	[0 to 4.5]	0.1	[-3 to 3.5]
12: weekly RADT + PCR	3.5	[0.5 to 8.5]	1.5	[-2 to 5.5]	2.6	[0 to 6]	0.8	[-2.5 to 4.5]
13: twice a week RADT + PCR	3.9	[0.5 to 9]	1.8	[-1 to 5.5]	2	[0 to 5.5]	0.2	[-1 to 1.5]
14: three times a week RADT + PCR	4	[0.5 to 8.5]	1.9	[-1.5 to 6]	2.7	[0.5 to 6.5]	0.9	[-2.5 to 4.5]
15: four times a week RADT + PCR	4	[0.5 to 9]	2	[-1.5 to 6]	2.7	[0.5 to 6.5]	1	[-2 to 4.5]
16: five times a week RADT + PCR	4.1	[1 to 8.5]	2	[-1.5 to 6]	3	[0.5 to 7.5]	1.2	[-2 to 5]

*Incremental relative to comparator. Process assumes that a positive RADT will be followed by confirmatory RT-PCR. A false positive is defined here as an individual returning a positive test despite not being infected with SARS-CoV-2. In the RADT based scenarios this is a positive RADT and a positive confirmatory RT-PCR test despite not being infected.

Table 4. Total number of RT-PCR and RADT tests conducted (per hypothetical 250 worker cohort in a month)

Scenario	Total number of RT-PCR tests		Incremental* number of RT-PCR tests		Total number of RADTs	
	Mean	95% CI	Mean	95% CI	Mean	95% CI
1 (comparator): monthly RT-PCR	174	[126 to 229]	-	-	-	-
2: no serial testing	32	[0 to 81]	-143	[-192 to -100]	-	-
10: monthly RADT + PCR	165	[122 to 214]	-10	[-54 to 33]	119	[95 to 141]
11: fortnightly RADT + PCR	176	[131 to 227]	1	[-48 to 50]	219	[174 to 262]
12: weekly RADT + PCR	251	[203 to 304]	77	[26 to 131]	492	[405 to 573]
13: twice a week RADT + PCR	188	[135 to 246]	13	[-16 to 49]	971	[792 to 1,136]
14: three times a week RADT + PCR	252	[202 to 311]	78	[29 to 130]	1,337	[1,114 to 1,566]
15: four times a week RADT + PCR	256	[202 to 315]	82	[28 to 133]	1,718	[1,399 to 2,034]
16: five times a week RADT + PCR	260	[203 to 327]	86	[31 to 142]	2,309	[1,856 to 2,736]

*Incremental relative to comparator

Table 5. Number of person-days in self-isolation or restriction of movements (per hypothetical 250 worker cohort in a month)

Scenario	Total		Incremental (relative to comparator)	
	Mean	95% CI	Mean	95% CI
1 (comparator): monthly RT-PCR	613	[120 to 1,175]	-	-
2: no serial testing	346	[0 to 875]	-267	[-734 to 68]
10: monthly RADT + PCR	604	[144 to 1,187]	-9	[-479 to 461]
11: fortnightly RADT + PCR	697	[210 to 1,288]	84	[-430 to 596]
12: weekly RADT + PCR	864	[300 to 1,478]	251	[-286 to 778]
13: twice a week RADT + PCR	817	[258 to 1,489]	204	[-100 to 614]
14: three times a week RADT + PCR	939	[373 to 1,648]	326	[-225 to 921]
15: four times a week RADT + PCR	956	[365 to 1,646]	343	[-213 to 891]
16: five times a week RADT + PCR	1,023	[413 to 1,779]	411	[-131 to 995]

Table 6. Number of FTE staff (per hypothetical 250 worker cohort in a month)

Scenario	Total		Incremental (relative to comparator)	
	Mean	95% CI	Mean	95% CI
1 (comparator): monthly RT-PCR	0.16	[0.11 to 0.23]	-	-
2: no serial testing	0.03	[0.00 to 0.07]	-0.13	[-0.19 to -0.09]
10: monthly RADT + PCR	0.29	[0.22 to 0.36]	0.12	[0.07 to 0.18]
11: fortnightly RADT + PCR	0.41	[0.32 to 0.51]	0.25	[0.18 to 0.33]
12: weekly RADT + PCR	0.79	[0.63 to 0.97]	0.63	[0.49 to 0.80]
13: twice a week RADT + PCR	1.27	[1.00 to 1.61]	1.11	[0.83 to 1.45]
14: three times a week RADT + PCR	1.75	[1.37 to 2.20]	1.58	[1.21 to 2.04]
15: four times a week RADT + PCR	2.18	[1.67 to 2.78]	2.02	[1.51 to 2.62]
16: five times a week RADT + PCR	2.85	[2.21 to 3.68]	2.69	[2.03 to 3.50]

Table 7. Cost of testing processes (per hypothetical 250 worker cohort in a month)

Scenario	Total		Incremental (relative to comparator)	
	Mean	95% CI	Mean	95% CI
1 (comparator): monthly RT-PCR	€14,542	[9844 to 20064]	-	-
2: no serial testing	€2,638	[0 to 6751]	-€11,904	[-16847 to -7879]
10: monthly RADT + PCR	€14,447	[10408 to 19407]	-€95	[-3825 to 3424]
11: fortnightly RADT + PCR	€15,979	[11496 to 20922]	€1,437	[-2455 to 5322]
12: weekly RADT + PCR	€23,951	[18243 to 30326]	€9,408	[4954 to 14282]
13: twice a week RADT + PCR	€21,563	[15844 to 27532]	€7,021	[3908 to 10960]
14: three times a week RADT + PCR	€29,174	[22798 to 36649]	€14,632	[9077 to 20458]
15: four times a week RADT + PCR	€31,820	[24876 to 39644]	€17,277	[11442 to 23595]
16: five times a week RADT + PCR	€35,754	[28084 to 45134]	€21,212	[14288 to 29606]

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