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Health Service Personal Protection Equipment Demand & Expenditure Estimation 2021

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Report Summary

Background:

- Recognising the unprecedented uncertainty faced by policy-makers in planning for the progression of COVID-19, Irish Government Economic and Evaluation Service staff in the Department of Health were assigned to develop the Personal Protective Equipment (PPE) Estimation Model, to provide for a **transparent, dynamic, evidence-based estimate** of required PPE for the Irish healthcare system.

Inputs and Process:

The Model consolidates a variety of data inputs to achieve its objective of estimating PPE need, including;

- Per Patient Per day PPE clinical guidance usage in various inpatient settings.
- IEMAG epidemiological curves scenarios.
- CSO, CHO, HSPC and HSE data for various inputs related to healthcare WTEs, COVID infections by care setting, COVID testing data, COVID Acute care occupancy data, GP Patient visits.
- Market Prices of PPE items (hand gel, surgical masks, gowns etc).
- Empirical Hospitalisation rates for COVID patients.
- Observed recovery times for COVID patients.

Output:

- The model anticipates a cost range of **€540m-€865m**[1] for PPE over a 52-week period for 2021.
- PPE spend in the **baseline scenario is an estimated c. €650m**.
- The model finds that **61%** of PPE cost is situated in the community residential setting.

Policy Implications:

- This work is intended to assist ongoing procurement and stock management of PPE, as well as to provide a transparent and evidence informed basis for estimating medium term PPE costs in the context of budgeting for annual health expenditures, within the health system.

- It is important to note that while significant progress has been made to ensure evidence informs this critical area of health policy, we recommend continuous consideration of the following to improve the effectiveness of policy, to ensure value for money and to reduce opportunity costs to the health service.

  1. The range of outcomes resulting from the scenario analysis is large (greater than €300m).
     As a result of this uncertainty, policymakers should be attentive to the range of possible outcomes that could occur rather than on the precision of the baseline number.

  2. There is a need to closely monitor and update the estimate with best available data throughout the year to improve the accuracy of forward-looking estimates.

  3. While the IGEES model provides considerable flexibility to policymakers, not all inputs are readily adjustable. The HSE's baseline clinical guidance used for the determination of per day PPE usage indicates an ongoing need for PPE largely unchanged by Covid-19 disease progression.

     This means that approx. €470m of the cost of PPE out of a total of approx. €650m is used for preventative purposes rather than direct care of COVID infected patients. Even if COVID was substantially suppressed in the country, PPE usage as prescribed by the current clinical guidance would remain very high relative to pre-COVID usage (€15m in 2019).

Contents

Acknowledgements:

Over the course of the development of the model, the modelling team received support from many colleagues within the public service.

In particular we are grateful to the Quality Assurance Group (QAG) members for providing a critical review of our analysis. Details of the QAG provided below.

Chair: Jasmina Behan (Head of IGEES)
Reviewers:

- Ronan O'Kelly, CSO Statistician, Department of Health.
- Conor Keegan, ESRI & NPHET IEMAG Sub-Group.
- Sean Lyons, ESRI & NPHET IEMAG Sub-Group.
- Cian McCarthy, IGEES, Health Vote, Department of Public Expenditure and Reform.
- Ben Breen, IGEES Central, Department of Public Expenditure and Reform.
- Tiago McCarthy & Clara Lindberg, Department of Health.
- Luke Rehill & Éamonn Sweeney, IGEES, Department of Finance.

Please note, the group is made up of personnel from a number of organisations, but the individuals and/or their critical review do not represent the views of their organisations.

All errors are the author's own.

1. Objective of the Model

The Department of Health PPE Estimation Model is an IGEES approved and externally reviewed transparent, dynamic, and evidence-based estimate of required PPE for the Irish healthcare system. The Model provides an estimate of PPE required for seven different care settings: Community Residential, Homecare, ICU, Non-ICU, GPs, Primary Care, and Testing. The Model incorporates anticipated COVID and Non-COVID patients per care setting, per-patient per day PPE usage, and PPE price per item to find an estimate of per-day PPE volume and cost by care setting.

The Model has two main objectives. The first is to provide an evidence-based mechanism for estimating medium term PPE cost in the context of budgeting for annual health expenditures. During the initial phase of the pandemic, both the short and medium term costs for PPE in Ireland were highly uncertain, with initial estimates forecasting a cost of over €1bn per year (RTE, 2020). The uncertainty surrounding this issue coupled with its very large budgetary impact motivated the Department of Health to develop an evidence-based approach to the estimation of these expenditures based on best available data and externally verified assumptions. Over the course of the development of the model, the modelling team received clinical advice and data from many colleagues within the HSE. It is the hope of the Department that this model will be a useful tool for estimating these expenditures for the duration of the COVID pandemic.

The second objective is to assist the health service with the ongoing procurement and stock management of PPE. For much of the pandemic, the market for PPE has been highly volatile, with prices and supply lines changing depending on the progression of the disease in various countries. While the market for PPE has calmed in the interim, concerns over shortages of certain PPE items and the active procurement of PPE in the event of a crisis remains an issue. By illustrating a per-week PPE requirement that dynamically responds to COVID infections, the model enables procurement personnel to estimate approximate PPE need over a specified period. Ultimately, this ensures that PPE spend is proportionate to need, lowering the likelihood of stock shortages or over-purchasing of PPE during periods of market volatility.

The paper is set out in sections as follows:

- Section 1 – Objective of Model
- Section 2 – Literature, Sources & Baseline Clinical Guidance
- Section 3: Methodology
- Section 4: Estimate Uncertainty and Limitations
- Section 5: Model Specification - 2020

- Section 6: Scenario Analysis - 2021 Estimate
- Section 7: Conclusion

2. Literature, Sources & HSE Baseline Clinical Guidance

A variety of sources were used in the development of the PPE estimation model. Given the novel and time sensitive nature of the project, a traditional research approach reliant on existing estimates of PPE demand could not be utilised. Instead, a bottom-up approach to modelling was utilised in line with the guidance and feedback we received from health practitioners.

Literature

At the start of this project, literature related to the change in the demand for healthcare services as a result of COVID in Ireland was sparse. While much had been written about the clinical and epidemiological characteristics of COVID, less attention had been given to the implications of COVID for healthcare provision. A welcome exception to this was the ESRI's Service Demand Model, developed as part of the Irish Epidemiological Modelling Advisory Group (IEMAG), subgroup 2 (Lyons & Keegan, 2020). The model provides projections of demand for acute care and critical care beds in Ireland as a result of COVID-19. Epidemiological forecasts of COVID-19 infections over several months, combined with the hospitalisation rate of COVID infected individuals is used to derive the average per-day/week demand for acute care beds. An average length of stay, denoting the amount of time a COVID infected individual spends in hospital is then used to inform occupation levels for beds for both acute care settings. The methodology employed by this model to forecast acute care beds informs our own method for estimating both acute and community care demand.

A briefing note released by Lyons and Keegan published several months after the publication of their initial model was also informative. Lyons and Keegan (2020a) describes the evolution of the hospitalisation and length of stay parameters in Ireland between March and August. They find that Hospitalisation rates for COVID infected individuals have varied between 24% and 2.2%, with the length of stay of COVID infected individuals varying between 14 and 5 days. Both of these outcomes have implications for our model, which uses hospitalisation rates and COVID length of stay as inputs.

Data Sources

While the reliance on contemporary literature for the model is relatively low, the different sources used for various model inputs is large. Owing to the expansive question, the quality, size, and veracity of each source the model uses is uneven. Nonetheless, every effort was made by the modelling team to find the best available data in question. A final note is that many of the data referenced in this section are subject to change. As evidenced by the review from Lyons and Keegan (2020a), our understanding of COVID is evolving on a continuous basis. As such, some of the information that we use to derive the relationships in the model may be subject to change.

1. Community Healthcare Organisation received data

Community Healthcare Organisation data is used for homecare, community residential and primary care settings to obtain suspected COVID patients in these settings, visits per day in homecare and primary care, and care setting capacity for primary care. Each Community Healthcare Organisation (CHO) has a designated PPE Lead that acts as the key interface between all relevant healthcare settings in their area to enable an efficient PPE management process. On a weekly basis, CHO leads communicate the following:

- Public, Private and Voluntary Nursing Homes - Max capacity and number of confirmed or suspected COVID patients.
- Care at Home - Number of patients currently receiving care at home, average number of visits per day and numbers of persons in receipt of care at home during COVID who are known/suspected COVID positive.
- Primary Care - Number of service users currently receiving HSE services during COVID, average number of attendances per day per service user, and numbers of persons in receipt of service during COVID who are known/suspected COVID positive.

2. Acute Care Confirmed Positive & Suspected Patients by week.

Acute care COVID positive and suspected patients between June and August were collected from a series of HSE Coronavirus daily operations updates. Daily COVID-19 updates, including the number of COVID confirmed and suspected cases in acute care settings are available from the HSE website (HSE, 2020).

3. Hospitalisation rates

Evidence on the hospitalisation rate for COVID is derived from two main sources:

a) HPSC daily Epidemiological Reports. These reports contain an aggregated COVID hospitalisation rate, calculated as the total number of COVID infected individuals hospitalized to date divided by the total number of COVID infections to date. (HPSC, 2020)

b) ESRI hospitalisations data cited in Lyons and Keegan (2020) and Lyons and Keegan (2020a). The variation in COVID hospitalisations rate by month reported by the ESRI is used to derive a range of possible values for hospitalisation, used to inform the high/low expenditure estimates of the model.

4. Acute Care Occupancy Data

Bed occupancy data for acute care settings between January 2019 and July 2020 was received from the Acute Care Business Intelligence Unit in the HSE. This data is used to provide a range of values for occupancy in 2020 and 2021.

5. CSO COVID Outbreak data

CSO outbreak data provides the total number of infected individuals in community residential and private homes. Data on the location of these outbreaks is used to allocate new COVID infections to the community residential and homecare settings (CSO, 2020).

6. Care Setting Capacity

Care setting capacity is used to estimate Non-COVID patients being treated per day. Capacity of each care setting, along with the source of these estimates is available below:

Table 1: Sources of Care Setting Capacity

Capacity by Care Area	Capacity	Source
Community Residential	43,900	HIQA data, and HSE National Service Plan 2020
Homecare	60,000	Actuals for Homecare service provision (DOH source) + provision for additional scheduled care in winter plan
Length of Stay COVID ICU	411	NOCA Data (Inpatient beds), and Unscheduled Care Lead HSE (Day beds)
V3 Pricing Contingency	15,157	NOCA Data (Inpatient beds), and Unscheduled Care Lead HSE (Day beds)

7. CSO hospitalisation data

CSO hospitalisations data provides a description of admissions to ICU and Non-ICU settings to date for COVID. This data is used to allocate new COVID infections into acute care settings in the model (CSO, 2020).

8. Testing data

The number of COVID tests processed per week was received from a Department of Health (DOH) official up to the 1st of September 2020. This is used to estimate testing demand in the model.

9. IEMAG Epidemiological Curves

Epidemiological Curves were received on the 18th of September from the IEMAG working group as part of the National Public Health Emergency Team. Four “Winter Surge” scenarios are provided, with the underlying assumption in all cases being that COVID cases rise significantly in the run-up to Christmas. For these scenarios, a projection is available until April 2021.

10. GP Patient visits.

Estimates of GP patient visits are provided from a number of sources:

a) A Figure for GP care was provided by the HSE GP Lead Advisor, who stated that in 2019 there were 28m GP visits. The ICGP Advisor also provided an estimate of 4.2m visits to GPs with flu-like symptoms, which is used to estimate suspected COVID patients in the model.

b) Another estimate for GP visits is taken from the Healthy Ireland Survey, which estimates just over 22.5m GP visits per year (Healthy Ireland, 2019).

An average of these two figures is taken for an estimate of GP visits in 2019, with this estimate informing GP visits modelled in 2020.

11. Surgical Mask – WTE Estimate

In the model, an additional allocation of PPE is made for preventative use of surgical masks. This is a result of a NPHET recommendation that all healthcare workers should wear masks, which was interpreted by the HSE as a one mask per hour allocation. This is incorporated using Healthcare WTE and patient visit data.

A range of sources were used to estimate the required number of preventative surgical masks, including:

- HSE employment reports (HSE, 2020).
- Estimates via the HSE Head of Performance, Contracting and Improvement in Community Operations.
- Estimates via the HSE National Oral Health Lead.
- Estimates via the HSE Human Resources Lead.
- Estimates via the HSE Head of Quality Assurance and Verification Division.
- Estimates via the HSE ICGP Lead.

HSE Clinical Guidance

In the context of the model, clinical guidance on per-patient per day PPE usage is an essential input for estimation of total PPE demand. For the purpose of the model baseline clinical guidance ("BCG") was provided via the National Clinical Lead for Infection Prevention and Control. These standards were developed in April through a mixture of direct observation and advice from various care setting leads. The Acute care PPE requirement was based on time in motion studies in two settings of a level 4 hospital (COVID ward and ED). Clinical visits to a nursing home informed the nursing home PPE requirement. Engagement with services contributed to PPE usage requirements for the remaining settings.

For each care setting, the clinical guidance specifies a per-patient per day allocation of PPE, including which items are required, and the number of these required per patient. PPE usage per patient is provided for both COVID and Non-COVID patients, owing to the increased need for preventative PPE use in light of the pandemic. The clinical guidance is specified for ICU, Non-ICU, Homecare, Community Residential, Testing Centres, Assessment Hubs, GPs and Primary Care, with each care setting receiving a different allocation of PPE per patient. An example of this clinical guidance in the context of per-patient ICU allocations is provided below:

Table 2 PPE Clinical Guidance for ICU care

PPE Item	Acute (ICU) (COVID)	Acute (ICU) Non Covid
Hand Gel - Large (1 Litre)	1.3	0.33
Standard & Extended Cuff Gloves	60	24
Goggles	4	0.2
Face shield	16	0.8
Gown	20	2
Aprons	20	10
FFP2 and FFP3 (Respirator) Masks	10	1
Type II (Surgical) Mask	10	3

Source: HSE Clinical Guidance.

Throughout the development of the model, the DOH sought to ensure that the clinical guidance provided by the HSE was consistent with PPE guidance internationally. Although divergence was detected between the Irish guidance and guidance in other countries, contextualizing these differences to an Irish healthcare setting was more difficult. For example, ECDC guidance proposes the use of different numbers of 'sets' of PPE items for suspected, mild and severe COVID cases, an elaboration omitted from the Irish guidance.

While the DOH had contended that this might be an appropriate distinction in the context of the Irish BCG, HSE representatives described the difficultly in applying this in a healthcare setting. Although in theory one can assign COVID patients into suspected, mild and severe groups in an ex-post analysis, on-the-fly identification of suspected versus confirmed COVID patients is much more difficult given the delays and false-negativity rate for COVID tests. Additional PPE usage differences are also highlighted internationally by Thomas et al. (2020). In their article, they compare PPE usage recommendations from Public Health England versus other International Health bodies. They conclude that even after several revisions, *"Public Health England guidance falls short of its* counterparts *in many clinical scenarios".* This illustrates the divergence in PPE usage guidance between countries.

While the majority of the issues identified with the BCG were resolved at an early stage, a remaining area of contention is the guidance surrounding preventative use of PPE. As it stands in the model, PPE usage for Non-COVID patients does not dynamically respond to the number of COVID patients present in a setting. This means approximately 59-81% of PPE spend is present irrespective of the prevalence of COVID in the country. Although this remains an outstanding issue between the HSE and the DOH, it was believed to be prudent to provide an estimate as the BCG stands for 2021 to enable efficient procurement of PPE.

3. Methodology

1. Patients:

- In the DOH model, inpatient care days are derived from COVID infections per day through several steps.[2]
  a. Data for forecasted COVID infections per day are taken from IEMAG scenarios.[3]
  b. These infections are then aggregated on a weekly basis to get new COVID infections per week.
  c. Once COVID infections per week is obtained, this is translated to Acute care patients using the hospitalisation rate from observed data (see Reference section in the model for further details).

$$\boldsymbol{New\ COVID\ cases^{4}\ per\ week} * hospitalisation\ rate = New\ COVID\ patients\ in\ acute\ care\ per\ week$$

  d. After finding the new COVID patients in acute care settings per week, we then need to convert this to patients in the system as a whole. This is achieved by referring to data from the CSO related to the distribution of COVID patients across settings. Outbreak data is used for Community Residential and Homecare settings to find the proportion of COVID infections in these settings as a % of total.
  e. Values for patients in each care setting are taken, and these figures are then divided by total patients to find the distribution of patients by care setting (%) as follows:

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[2] The model estimates testing based on an average of testing actuals over a 20-week period from the 20th of March. A contingency is then added to estimated testing to ensure that 15000 tests per day can be delivered if required. Visits to GPs and Primary Care providers are modelled based on received data from HSE & CHOs.

[3] Infections are modelled under IEMAG scenario 7, wherein R0 = 0.5 up to the 29th of June after which restrictions are relaxed. This increases the R0 to 1.2, for seven weeks, at which point restrictions are reintroduced and R0 falls back to 0.5. Week 37 to 52 of the model is based on the average of infections over the modelled period (Week 18 to 36).

[4] While cases are referenced in these equations, our epidemiological scenarios only capture COVID infections which have a positive diagnosis. As such, our outputs are derived from this input rather than total infections in the population (including unconfirmed COVID infections).

Table 3: Distribution of COVID Patients by Care Setting (Actuals + Estimates %)

Community Residential	**45.72%**
Homecare	21.76%
ICU	3.51%
Non-ICU	29.01%
Total Acute Care Patients (Non-ICU + ICU)	**32.52%**
Total Non-Acute (Residential + Homecare)	**67.48%**

f. Once this is found, we can then convert new COVID patients in acute care settings per week to new COVID patients per week (total).

g. We take the reciprocal of the proportion of total patients in acute care (32.52%) and multiply our new COVID patients in acute care per week to find Total new COVID patients per week.

h. In our modelling approach, we use the hospitalisation rate & acute care patients as anchoring figures to determine new patients each week. This is because infections in non-acute care settings are likely to be related to admissions for acute care. If the hospitalisation rate rises, this indicates that individuals from more vulnerable groups (such as those in homecare and community residential care settings) are being infected more than previously. By using hospitalisations as an anchoring figure, community residential infections and homecare infections adjust alongside changes in the hospitalisation rate. An additional advantage of this approach is that we directly observe the hospitalisation rate for COVID patients, meaning that it is the most reliable information we have on the relationship between infections and patients.

$$new\ COVID\ Patients\ in\ Acute\ Care\ per\ week * \left(\frac{1}{0.3252}\right) = Total\ New\ COVID\ patients\ per\ week$$

i. This is then converted to the new COVID patients in each care setting by making further reference to the above distribution:

$$Total\ New\ COVID\ patients\ per\ week * COVID\ patients\ in\ care\ area\ X\ (\%) = New\ COVID\ patients\ in\ care\ area\ X$$

2. Length of Stay:

a. If a patient is infected in week 1, then this patient needs care days allocated to them not only on the week they are infected but also for the weeks they remain in hospital/infected with COVID.

b. This is integrated into the model using a "Recovery time" or "Length of Stay" parameter. For example, to calculate COVID patients receiving care in week 2 (t=2), we need to also account for the proportion of patients infected in week 1 (t=1) who remain in hospital (suppose the recovery time is 11 days). This can be illustrated by the following equation:

$$new\ COVID\ patients\ in\ care\ area\ X_{t=2} + new\ COVID\ patients\ in\ care\ area\ X_{t=1} * \frac{11-7}{7} = total\ COVID\ patients\ in\ area\ X\ receiving\ care\ in\ week_{t=2}$$

3. COVID suspected patients

a. Based on clinical guidance for PPE usage, the model assumes that suspected COVID patients are provided with the same amount of PPE as confirmed positive cases until they are confirmed as COVID positive or negative.

b. The model assumes a testing time for COVID of 3 days.

c. The model further assumes that all suspected COVID patients in healthcare settings receive a COVID test, in line with clinical guidance received.

d. Suspected patients are calculated based on the proportion of suspected to confirmed positive cases observed in each care setting, utilizing observational data from CHOs and the HPSC. The proportions of suspected versus confirmed patients in each care setting are as follows:

Proportion of COVID Suspected to COVID Confirmed Patients by Care Setting	
Homecare	40.8
Community Residential	37.8
Non-ICU	9.4
ICU	0.7

e. Suspected patients are then discounted by (3/14), in line with the testing time for a COVID patient and the number of days on average a confirmed positive patient is treated as a COVID risk for.

f. Taking Total COVID patients in area X receiving care in Week t=2 from the last equation, we then add to this our suspected patients (new COVID patients in week t=2 times the proportion of suspected) and then discount it by (3/14) to find our effective number of total COVID patients in week t=2.

$$total\ COVID\ patients\ in\ area\ X\ receiving\ care\ in\ week_{t=2} + (new\ COVID\ patients\ in\ care\ area\ X_{t=2}) * \left(proportion \frac{suspected}{actuals}\ in\ care\ setting\ X\right) * \left(\frac{3}{14}\right) = Total\ COVID\ Patients\ Including\ Suspected\ in\ care\ area\ X\ in\ week_{t=2}$$

g. Once Total COVID patients receiving care in each week including suspected patients has been derived, we then multiply this by 7 to account for daily allocation of care to these individuals.

h. This gives us the care days allocated to COVID patients in each care setting per week, allowing us to calculate PPE usage on a given day in each care setting.

$$Total\ New\ COVID\ Patients\ Including\ Suspected\ in\ care\ area\ X\ in\ week\ t * 7 = Care\ days\ allocated\ to\ COVID\ patients\ in\ care\ area\ X\ in\ week\ t$$

4. Non-COVID Patients

a. Non-COVID patients are calculated as the patient capacity of a care area minus the number of COVID patients it currently has.

b. This importantly assumes occupancy of the whole capacity of a given care area. The capacity of care areas used in these calculations is static and is available in point 5 of the “Sources” section of this paper.

$$Capacity\ of\ Care\ Area\ X - Total\ New\ COVID\ Patients\ Including\ Suspected\ in\ care\ area\ X\ in\ week\ t = Non - COVID\ patients\ in\ area\ X\ receiving\ care\ in\ week\ t$$

c. In line with the conversion for COVID patients, this is then multiplied by 7 to find the care days allocated to Non-COVID patients in that care setting for a given week:

$$Non - COVID\ patients\ in\ area\ X\ receiving\ care\ in\ week\ t * 7 = care\ days\ allocated\ to\ Non - COVID\ patients\ in\ care\ area\ X\ for\ week\ t$$

5. Volume

a. Once COVID and Non-COVID care days for a given care area have been found, we can aggregate these days for the desired modelled period.
b. In our case, we sum the weekly care day total for 52 weeks to find the total COVID care days for the year.
c. We then use the BCG Clinical Guidance provided in the HSE model to convert care days in a given care setting for the year into PPE usage in that care setting for a year.
d. This calculation is done for each relevant PPE item, such as for hand gel, face masks, goggles, and gowns.
e. BCG guidance is given on a per-patient per day basis, so we need only to multiply our total care days in each setting by the BCG guidance for usage of that item.

$$Total\ Care\ days\ in\ setting\ X * BCG\ guidance\ for\ PPE\ usage\ of\ item\ A = Volume\ of\ PPE\ required\ for\ care\ setting\ X\ for\ item\ A$$

6. Cost

a. Finally, cost of PPE in each care setting is calculated through the multiplication of PPE volume by the average price of a given item.

$$Volume\ of\ PPE\ required\ for\ care\ setting\ X\ for\ item\ A * Price\ of\ Item\ A = Total\ cost\ of\ PPE\ item\ A\ for\ care\ setting\ X\ (EUR)$$

b. For both our volume and cost figures, we can then sum the respective PPE usage for each care area to find the overall PPE requirement for the estimate period (Items and EUR).[5]

[5] Preventative Surgical Masks are calculated on a WTE/ patient visit basis in the model. This is the result of guidance from NPHET stating that all healthcare workers should wear surgical masks and change mask once per hour.

4. Estimate Uncertainty and Limitations

While best efforts have been made to ensure that the model is as accurate as possible, it is important to highlight some of the areas that are most limiting to our analysis.

a) Estimate Uncertainty, Error and Contingency, (Epistemic Arrogance):

All forecast estimates are just that – estimates, not precise predictions of future events. This highlights the importance of model error rates. Error rates that pertain to forecasts of the routine will be lower than those that pertain to the novel. Put another way, the accuracy of an estimate is usually greater when estimating the regular rather than the irregular. Covid-19 is novel, and therefore highly irregular in terms of estimation. Furthermore, recent empirical analysis has shown that contagious diseases durations and severity exhibit "fat-tail" distributions, (Nassim Nicholas Taleb, 2020). This leads us to infer that in addition to the high levels of estimate uncertainty, the event in which we are trying to forecast is susceptible to the "Black-Swan" phenomenon.

It is important that this uncertainty is not simply acknowledged but accounted for formally in the policy analysis. To the greatest extent possible, this is recognised in our analysis in a number of ways as outlined below:

i. **Estimate range**:
   a. When dealing with high levels of uncertainty, the policies we need to make decisions on should depend more on the range of possible outcomes than on the precision of the final number.
   b. As such, each adjustable parameter is set in the context of a Low, Baseline and High estimate, to allow for a detailed scenario and sensitivity analysis, as advised by section 4.9.2 of the Public Spending Code (PSC, 2019).
   c. In each scenario, down to the granular level of PPE item, we have an estimated range of volume and expenditure amounts (see section 5). Within the range of scenarios heterogenous sensitivities have been applied to individual inputs to convey the range of possible outcomes under each scenario.
   d. The purpose of the scenario analysis is not to be mistaken as an assessment of event probability. What is more important for the policymaker to attain from this piece of the analysis is to have a clear idea of the potential consequences of the scenario, regardless of the probability of the scenario, i.e. the impact of the improbable, (Taleb, 2007, 2010).

ii. **Contingency**: When dealing with uncertainty it is important for policymakers to invest in preparedness over precision. As such, multiple contingencies are incorporated into the model, such as a 0-10% wastage contingency, and the use of COVID scenarios that incorporate winter and potential surges. Furthermore, potential parameter volatility is incorporated into the modelling scenarios used, with certain estimates incorporating higher COVID hospitalisation rates, COVID length of stay, Higher GP visits and other changes. This mitigates the risk associated with the potential variation in these parameters. Contingency is also present within the Baseline Clinical Guidance for PPE usage, with Precautionary PPE usage for the treatment of Non-COVID Patients comprising between 59% and 81% of overall PPE usage for 2021.

b) Calculation of Suspected Patients

The calculation of suspected patients is based on an average of the proportion of suspected versus confirmed cases for each care setting based on received data from CHOs and the HSE. Although this method incorporates the best available data to the modelling team at the time, it leaves a large room for error in a longer-term forecast. One would expect that over time the behaviour of clinicians with regards to the identification of COVID suspected patients may change as they become more familiar with the specific characteristics of the disease. This variable could also change depending on changes in Ireland's COVID testing regime. This means that the static proportions of confirmed vs suspected COVID patients may not be fit for purpose as better data becomes available.

c) Distribution of COVID patients by Care setting – Homecare

The distribution of COVID patients given a COVID infection is based on an approximate relationship between acute care patients and community care patients. While good data exists for COVID patients in acute care and community residential settings, no such data is collected for homecare patients. This means that specifying the allocation of COVID patients to homecare is difficult, with a poor proxy (outbreaks in private homes) used as the best available data for its estimation. In the future, the modelling team would hope to update this parameter based on actual observations of infections in the Homecare setting.

d) Parameter Variance

As has been highlighted, many of the parameters used in the model are at present highly variable. Given the small amount of collective experience we have with COVID, it is likely that some of the parameters used in the model will change as more data becomes available. As this occurs, it will reveal areas of the current model that over or underestimate PPE demand relative to the actual allocation required.

5. Model Specification - 2020

The baseline configuration of the model is specified as follows:

Model Parameter	**2020 Baseline**	**Source**
Hospitalisation rate	11.5%	ESRI (2020) and HSPC data
Healthcare Capacity (%)	83%	BIU Occupancy Data.
Length of Stay (Non-ICU, Community)	11.5	ESRI (2020)
Distribution of COVID patients Across Care settings	Baseline	CSO actual outbreak data
Epi Curve Scenarios	R 1.4, 0.7, 1.1, 1.4, 0.7	IEMAG
Wastage Contingency	5.0%	HSE
Covid Infections Contingency	-5.0%	DoH
% GP visits vs 2019	95%	HSE
Homecare Visits per day	1.70	HSE
Primary Care Visits per day	1.40	HSE and DoH
Testing (19-week average = 100%)	200%	ESRI
Length of Stay COVID ICU	15.5	HSE
V3 Pricing Contingency	-5%	HSE and DoH

Table 4: 2020 Output

Scenario	Baseline	High	Low
EUR M	**€687**	**€854**	**€600**

Table 5: 2020 PPE Requirement by Volume & Cost

PPE Item	Volume	Volume %	Cost	Cost %
Hand Gel - Large (1 Litre)	11,335,430	1%	€ 153,141,666	22%
Standard & Extended Cuff Gloves	541,396,444	41%	€ 113,693,253	17%
Goggles	6,687,829	1%	€ 18,324,652	3%
Face shield	25,477,512	2%	€ 35,413,741	5%
Gown	39,473,397	3%	€ 184,735,499	27%
Aprons	264,569,697	20%	€ 31,748,364	5%
FFP2 and FFP3 (Respirator) Masks	5,022,263	0%	€ 11,048,978	2%
Type II (Surgical) Mask	5,022,263	0%	€16,218,921	2%
Type II (Surgical) Mask (HSE Model)	405,848,808	31%	€ 119,822,029	18%
Total	**1,304,833,642**		**€ 684,147,103**	**100%**

- Baseline spend expenditure for PPE in 2020 is €687m.
- The range of outcomes defined by the high and low scenarios is large, with the high scenario being €167m above the baseline, and the low scenario being 87m below the baseline.
- This highlights the sensitivity of the model to small variances in its parameters, and most importantly the large range and variance can be interpreted by policymakers as a direct indication of the uncertainty attached to the estimate. (See section 4).

6. Scenario Analysis: 2021 Estimate.

In order to provide an estimate of 2021 PPE demand and expenditure, (whilst acknowledging the data limitations and uncertainty present in our model with the data limitations), and realistic expectations around the degree of predictability of a novel disease over a 12-month period, we take the 2020 scenario as the counterfactual, and make adjustments around this central scenario to estimate the 2021 position.

The 2021 parameters adjustments made in comparison to the 2020 counterfactual are shown below, along with the 2021 parameter value and the rationale behind the adjustment. It is again important to note that although we have attempted to greatest extent possible to reduce subjectivity in this scenario analysis by adjusting relative to the previous parameter range, the model specification for 2021, is predominantly a qualitative exercise, then applied quantitatively.

Table 6: 2021 Parameter Adjustments versus 2020

Hospitalisation rate	**Static**
Healthcare Occupancy	**Static**
Length of Stay	**Static**
Distribution of COVID patients (Community residential infections)	**Static.**
EPI Curves/COVID infections	**Lower**
Wastage Contingency	**Static**
% GP visits relative to 2019.	**Lower**
Homecare visits per day	**Higher**
Primary Care visits	**Higher**
Testing contingency	**Higher**
Pricing	**Lower**
BCG Clinical Guidance	**Static**

*vs 2020 counterfactual.

The changes to be made for 2021 versus 2020 are as follows:

- **Epi Curve Scenarios/Aggregate COVID Infections** – The 2021 estimate for PPE incorporates a lower number of total COVID infections for 2021 than for 2020. This is due an increased awareness of the virus in the community and in healthcare settings, better understanding of public health measures, and the lack of the initial spike that we observed in March 2020. The epidemiological scenarios used for 2020 already provide an upper bound estimate, incorporating the initial infection spike and two larger infection waves around the winter period. As a result, an infection contingency has been used for the baseline and low scenario, reducing infections by 5% and 10% respectively.

- **Homecare Visits per week** – Homecare visits in 2020 are believed to have been suppressed by the prevalence of the virus in the community. For 2021, the HSE has indicated in its Winter Plan that homecare provision will increase, with corresponding implications for homecare visits per week. Homecare visits per day have thus been increased for the baseline scenario from 1.5 in 2020 to 1.7 in 2021.
- **Primary Care visits per week** – Primary care visits have likely been suppressed by the prevalence of COVID. In 2021, it is believed that Primary care visits will return to a more regular level of activity than in 2020. Primary care visits have been increased from 1.3 to 1.5 for 2021.
- **Testing Contingency/Tests per week** – The Irish government has committed to an increase in the number of COVID tests provided in 2021. Alongside this expectation, the DOH modelling team has increased the contingency for testing to ensure that a capacity for 100000 tests a week can be maintained.
- **Pricing** – The DOH expects that improved conditions in international markets, coupled with an increased supply of domestic PPE items will result in reduced prices for PPE. The baseline and low scenarios have been reduced by 5% and 10% respectively.

Table 7: list of the parameters used for the high, low and baseline scenarios for 2021 is as follows:

	High	Baseline	Low
Hospitalisation rate	13.50%	11.50%	8.30%
Healthcare Capacity (%)	93%	83%	75%
Length of Stay (Non-ICU, Community)	14	11.5	10.5
Distribution of COVID patients[6]	High	Baseline	Low
Epi Curve Scenarios	R 1.1, 1.6, 0.7	R 1.4, 0.7, 1.1, 1.4, 0.7	R 1.4, 0.7, 1.1, 1.4, 0.7
Wastage Contingency	10.00%	5.00%	2.50%
Covid Infections Contingency	0%	-5.00%	-10%
% GP visits vs 2019	100%	95%	90%
Homecare Visits per day	2	1.7	1.5
Primary Care Visits per day	1.5	1.4	1.3
Testing (19-week average = 100%)	250%	200%	150%

[6] The distribution of COVID patient’s parameter changes how new patients are allocated across care settings by the model. The “High” scenario envisions a situation where nursing home infections are higher than in the baseline counterfactual, with lower numbers of homecare patients. Similarly, the “Low” scenario envisions a situation where nursing home infections are lower than in the baseline scenario, with higher infections in homecare. Per Patient PPE usage is much higher in community residential settings than in homecare settings.

Length of Stay COVID ICU	18	15.5	14
V3 Pricing Contingency	0%	-5%	-10%
Total	**€865**	**€655**	**€540**

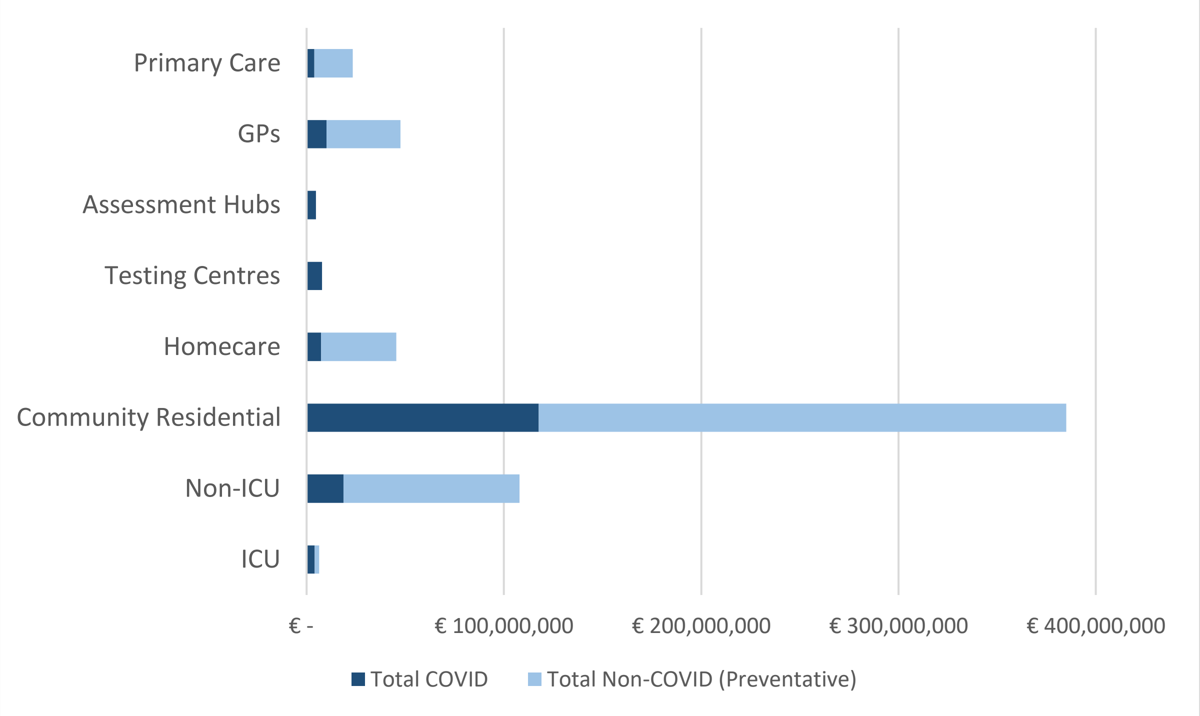
Table 8: Total PPE cost for 2021 under our three scenarios specified is outlined below:

2021 Estimate Breakdown	Baseline	High	Low
Hand Gel - Large (1 Litre)	€148M	€185M	€125M
Standard & Extended Cuff Gloves	€112M	€137M	€96M
Goggles	€17M	€28M	€12M
Face shield	€33M	€53M	€23M
Gown	€173M	€260M	€130M
Aprons	€31M	€37M	€27M
FFP2 and FFP3 (Respirator) Masks	€10M	€19M	€6M
Type II (Surgical) Mask	€16M	€22M	€13M
Type II (Surgical) Mask (HSE Model)	€114M	€124M	€106M
Total PPE Cost	**€650M**	**€865M**	**€540M**
*numbers may differ slightly (1%) from the manual calculation due to rounding for presentation purposes.			

- Total PPE cost for 2021 in the baseline scenario is €653m.
- This compares to €687m in 2020, or a 5% reduction in spend.
- The range between scenario values remains high, with the difference between the high and low scenarios at €327m for 2021.
- This highlights the sensitivity of the model to small variances in its parameters, and most importantly the large range and variance can be interpreted by policymakers as a direct indication of the uncertainty attached to the estimate. (See section 3).

PPE spend on an itemised basis is most intensive for Gowns, Gloves, Hand Gel and Surgical Masks. Between March and August 2020, prices for all PPE items declined by an average of 32%. An exception to this was hand gel, which increased in price by 76% between March and August. Although much volatility was experienced in 2020 for the price of these items, it is expected that improving market conditions and an increased domestic supply will mediate this variance going forward. This is also reflected in the parameter applied to PPE prices in 2021, reducing prices by between 5 and 10 percent.

Figure 1: PPE Spend by Care Setting



PPE spend by care area is uneven, with PPE spend in the Community residential setting making up 61% of total PPE expenditure. The other largest spend areas are Non-ICU acute care (17%), GPs (8%) and Homecare (7%).

It can also be noted that expenditure on preventative use of PPE, highlighted in light blue makes up a significant proportion of total expenditure. As noted, under the current clinical guidance this expenditure is required irrespective of the number of COVID cases in the country.

7. Conclusion

This staff paper has provided an illustration of the Department of Health PPE Estimation Model, including its data sources, methodology and key insights.

The key contributions of the analysis are as follows:

- A transparent and externally reviewed Budget estimate.
- The difference between the high and low estimates provided by the model is over €300m, highlighting the sensitivity of the model to variation in parameters, and the large amount of uncertainty related to a model of this nature. This should signal to policymakers the need to closely monitor this estimate, with a continuous iterative process, updating the estimate with best available data throughout the year.
- The majority of PPE usage is used in the treatment of non-COVID infected individuals for the purpose of mitigating infection risk. Current clinical guidance for PPE usage does not change dynamically with COVID infections, meaning that approx. EUR €470m of the cost of PPE out of a total of approx. EUR €650m is use for preventative purposes rather than direct care of COVID infected patients.

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Quality Assurance process

To ensure accuracy and methodological rigor, the author engaged in the following quality assurance process.

- ☐ Internal/Departmental
  - ☑ Line management
  - ☐ Spending Review Steering group
  - ☑ Other divisions/sections
  - ☑ Peer review (IGEES network, seminars, conferences etc.)
- ☐ External
  - ☑ Other Government Department
  - ☑ Quality Assurance Group (QAG)
  - ☑ Peer review (IGEES network, seminars, conferences etc.)
  - ☑ External expert(s)
- ☐ Other (relevant details)