# HOW TO PRIORITISE **VACCINATION**

**Remarkably, mankind has developed a range of vaccines in little more than 12 months since the identification of the novel coronavirus in late 2019. The big issue as we enter 2021 is how should those vaccines most responsibly be rolled out? Stuart McDonald, Yifei Gong and John Roberts, three actuaries working on demographic and epidemiological data, have been to the fore of analysis of the benefits of the strategic distribution of early vaccines to the most vulnerable categories of the population. We set out here a summary of their recent work.**

**IN THE UK, THERE WERE 9 PRIORITY GROUPS IDENTIFIED. BROADLY SPEAKING THEY WERE:**

1. residents in care homes, together with care home workers
2. over 80s, together with health care staff
3. over 75s
4. over 70s and clinically vulnerable
5. over 65s
6. people under 65 with health issues
7. over 60s
8. over 55s
9. over 50s
10. the rest

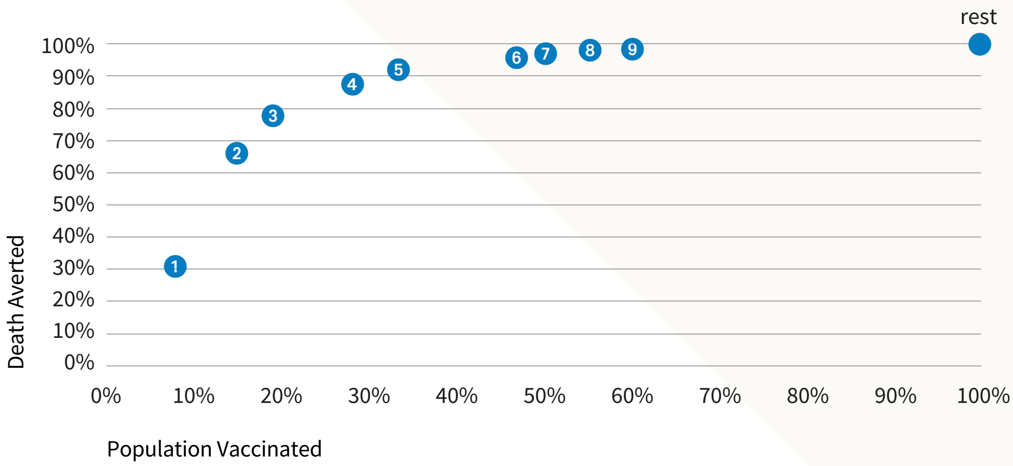
Using actuarial techniques, the groups were analysed to see what proportion of COVID-19 deaths had occurred in each segment of the population and what proportion of the population fell into each category. Acquiring suitable data in an emerging pandemic is difficult but Governments have collected copious material to enable them to monitor the situation. The modelling was done on the basis of COVID-19 attribution featuring on certificates of death as a reasonably objective piece of information.

The population of England was analysed to categorise the population by group and to analyse the death data into the same groups. Some approximations were needed but the majority of the age-related categories were easily extracted. A table was then built up to show the proportion of deaths that might have been saved with an effective vaccine having been delivered to that category. Clearly, the vaccine might not be totally effective and vaccination not carried out to the full, but the relative impact of each category is clearly seen in the data.

At its simplest, how many vaccinations are required to prevent one death:

| Priority Group | Percentage of Population (Cumulative) | Number of vaccines required to save a life | Percentage of Lives Saved (Cumulative) |
|---|---|---|---|
| 1 | 2% | 10 | 32% |
| 2 | 15% | 90 | 67% |
| 3 | 19% | 180 | 78% |
| 4 | 28% | 360 | 88% |
| 5 | 33% | 570 | 93% |
| 6 | 47% | 2000 | 96% |
| 7 | 50% | 900 | 97% |
| 8 | 55% | 1800 | 98% |
| 9 | 60% | 3500 | 99% |
| The rest | 100% | 23000 | 100% |

FIGURE 1. DEATHS PREVENTED VS POPULATION VACCINATED BY PRIORITY GROUP



It can be seen that the first four priority groups (targeted by mid-February 2021 in the UK) cover 28% of the population but 88% of the probable deaths.

It is also important to note that there are good reasons to get vaccinated beyond reducing our own risk. We get vaccinated to protect others, by breaking chains of transmission, as much as to protect ourselves.

This work also uses a simple analysis of death counts rather than an alternative such as Quality Adjusted Life Years (QALYs), which would place more value on younger lives. Whilst a QALY approach would have merit, a simple analysis seems appropriate here, given the relatively short time interval expected between the different priority groups becoming eligible for the vaccine and the likelihood that full population vaccination will not be long delayed in any case.

A further public debate has concluded in the UK with the decision to prioritise the first dose of a two-dose vaccination programme on the basis that it is likely (though not demonstrably certain) that most of the life-saving and hospital-saving impact will arise with the first dose and that it is better to administer one dose to twice as many people as two doses to the first groups. Clearly it is possible that the second dose to the highest categories just might save more than the first dose to the accelerated lower categories but the data to demonstrate this does not exist and a political decision was taken in the UK unlike most other states.

## HOSPITAL ADMISSIONS

The public debate is further coloured by discussion about whether the focus should be on the avoidance of preventable deaths or hospitalisations and consequent pressures on the health system, with the ensuing impact on the conduct of non-urgent normal healthcare. Fortunately, the data does lend itself to further analysis of the impact of vaccination on reducing hospital admissions.

There is a logical order to studying the impact of the virus. Cases precede hospitalisations (and in some cases intensive care), with deaths following. We also needed to build in the period before the vaccine becomes effective in preventing illness – we know from the medical trial data that it is possible to be infected up to two weeks after the first shot. The impact of this additional period will be important to understand, as an anxious public is waiting to see the first positive effects of the vaccination programme.

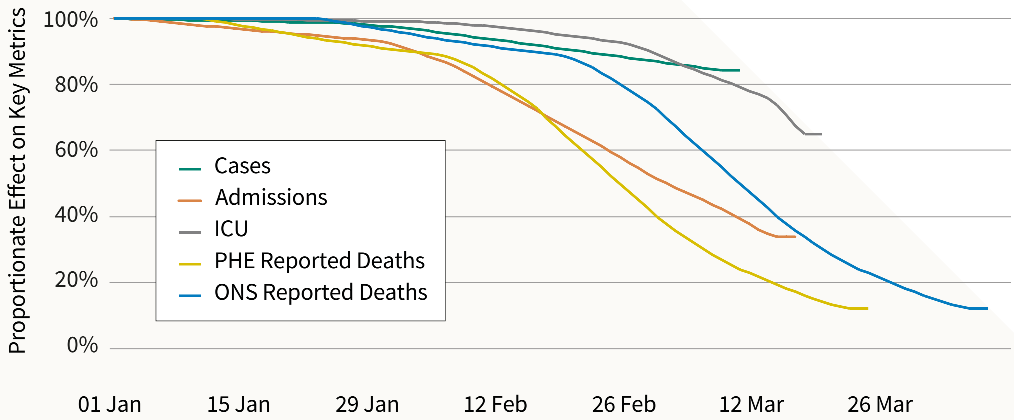
## INFLUENCING FACTORS

The overriding influence is the prevalence of the virus. For simplicity, the analysis assumed constant prevalence, and so recent falls since the latest lockdown started will add to the benefit shown. The vaccination will not be 100% effective, and neither will we see a 100% take-up from those offered the vaccine. Vaccine effectiveness will also affect measures in different ways. For instance, an effectiveness of 70% may only reduce cases by that amount, but would hopefully reduce serious illness and death by a much greater percentage. In contrast, the take-up rate will affect each measure in a consistent and intuitive way. However, as the early phases are concentrated on the most vulnerable, and those who are caring for them, it is reasonable to assume that there will be a relatively high take-up rate – certainly greater than would typically be seen with the annual flu vaccination programme.

### Cases

The analysis considered how long it is likely to be before we start to see an effect in the various reported statistics. It should be noted that these are estimated average delay periods. In reality there is a spread of actual delays around the mean. Allowing for the two-week period after vaccination before protection kicks in, a further three to four days is typical for the first symptoms to occur, and we should allow another two to three days for a test to be taken and the results to be reported in the data published. Overall 20 days was assumed.

FIGURE 2. VACCINE EFFECT (GROUPS 1 TO 4 ONLY)




### Hospitalisations

Added to the two-week effectiveness delay, following infection there is typically a 10-day period before admission to hospital, plus two days for reporting which translated to an assumption of 26 days.

### Hospital deaths (PHE)

These are on average 6 to 8 days after hospitalization plus around 3 days for reporting delays which resulted in an assumption of 34 days.

### ONS Deaths (National Statistics)

With a focus on excess deaths, as reported by ONS, it is also useful to understand the additional delay period before these begin to be impacted. Registrations are reported weekly, with a 10 to 16 (average 13) day lag from registration, to which the period between death and registration should be added. This latter delay can be very variable, and extend into many weeks in some instances. However, given that the majority of deaths are recorded within a week, the analysis assumed a further delay of 3 days. Adding this to the 31 days from the hospital deaths estimate above gives a total period of nearly nine weeks produced an assumption of 47 days.

The modelling then took these periods of time and identified these with the schedule for vaccination drawn up by the authorities for these priority groups in order to show the likely impact on the reported data and the implied pressures on hospitals and their Intensive care facilities.

The graph above shows the currently estimated timescale impact from vaccinating the first four priority groups on the likely reduction both in deaths and in hospitalisations. It shows clearly that whilst we should expect a rapid fall in deaths, the first four priority groups will have a lesser impact on hospital admissions, and an even smaller impact on intensive care (ICU) admissions, where very few of the oldest patients will be considered clinically to benefit from the treatment available.

This is a moving subject and one where actuaries have been able to produce information of critical importance to public policy decision-making, particularly by elected politicians making a balance of judgments. There will be more decisions to take on the way and the speed at which society's normal behaviour can commence again and professional actuarial modelling of this kind should enable better judgments to be made.