Discrepancies and inconsistencies in UK Government datasets compromise accuracy of mortality rate comparisons between vaccinated and unvaccinated

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27 October 2021

Abstract

To determine the overall risk-benefit of Covid-19 vaccines it is crucial to be able to compare the all-cause mortality rates between the vaccinated and unvaccinated in each different age category. However, current publicly available UK Government statistics do not include raw data on mortality by age category and vaccination status. Hence, we are unable to make the necessary comparison. In attempting to reverse engineer estimates of mortality by age category and vaccination status from the various relevant public Government datasets we found numerous discrepancies and inconsistencies which indicate that the Office for National Statistics reports on vaccine effectiveness are grossly underestimating the number of unvaccinated people. Hence, official statistics may be underestimating the mortality rates for vaccinated people in each age category. Although we have not subjected this data to statistical testing the potential implications of these results on the effects of vaccination on all-cause mortality, and by implication, the future of the vaccination programme is profound

Introduction

In a previous article[1] we argued that the overall risk/benefit of vaccines was best measured by comparing all-cause mortality between the vaccinated and unvaccinated. A simple summary of our arguments for this is provided in the Appendix. Our article reviewed the Public Health England (PHE)/Office for National Statistics (ONS) data on age-adjusted mortality rates by vaccination status [1]. In the most recent week of that report (week 26, ending 2 July 2021) the ONS provided the data, which is shown in Table 1, along with the ASMR (age standardized mortality rate) that is derived from it.

Table 1 All cause deaths by vaccination status (week 26)

	Population size	Total all-cause deaths	Unadjusted mortality rate (UMR)	Age standardized mortality rate (ASMR)*
Unvaccinated	9,531,364	436	4.57	25.3
One dose	6,404,395	576	8.99	89.3
Two doses	23,309,568	5944	25.5	14.7
Total	39,245,327	6,956	17.72	-

* Note that the ASMR here is derived by weighting the ASMR values for Covid-19 (Table 4) and Non Covid-19 deaths (Table 5) from [1]

[1] https://probabilityandlaw.blogspot.com/2021/09/all-cause-mortality-rates-in-england.html

The 'unadjusted' mortality rate (UMR) is simply the number of deaths per 100K people (i.e., we divide the total all-cause deaths by the population size and multiply by 100K). The ASMR [2] is a derived metric to adjust for the different age distributions among the different groups (the ONS did not provide the ASMR for the total population, hence the blank entry in the final column of Table 1). It should also be noted that just 109 (less than 1.6% of the total 6956 deaths) were classified as Covid-19.

The large differences both within and between the UMR and ASMR numbers in Table 1 seem highly counter-intuitive and, while some differences have obvious explanations, others do not. Specifically:

- The unvaccinated group has the lowest UMR (five times lower than the rate for people with two doses), but the two-dose vaccinated group has the lowest ASMR. As explained in our previous article, this 'reversal' is an example of Simpson's paradox and is explained by the fact that most deaths occur in the older age categories which are also the categories with the highest percentage of double vaccinated people.
- While the ASMR for the two-dose vaccinated group is lower than the UMR, the one-dose vaccinated group ASMR is ten times higher than the equivalent UMR. This is hard to explain, as is the extremely high ASMR for those one-dose vaccinated.
- The total population size of 39,245,327 in the ONS/PHE mortality by vaccination status report [1] is supposed to include everybody in England aged at least 10 but is at least 10 million fewer than that estimated by ONS in the 2011 census [9] and in their 2021 population estimate [10]. In fact – as confirmed in direct discussions with ONS – the missing millions is explained by the fact that the ONS use a cohort based on people who responded to the 2011 Census and were registered with a GP in 2019 (to remove potential emigrants).

While the ASMR can be useful in many epidemiological and medical contexts, we believe it is both unnecessarily complex – and somewhat redundant – in this context. The ASMR maps any population onto a notional European standard age population profile [2], and its calculation depends on the population size and number of deaths in each of a full range of age stratification categories for each vaccination category. The fundamental problem we noted in our article was that the ONS did not provide this raw data and so it was therefore impossible to verify their ASMR calculations.

If we had the raw age-categorized data we would be able to simply compare, for each age category and week, the all-cause mortality rate for vaccinated and unvaccinated. This would make the ASMR redundant and allow the direct comparison we seek. The ONS have told us in direct communications that release of this age-categorized data is planned for future versions of the vaccination status reports and have committed to make this release within the next three weeks.

Discrepancies and Inconsistencies in ONS datasets

While the data are not yet directly available, we believed it should be possible to reverse engineer reasonably accurate mortality ***estimates*** for the individual age categories, by vaccination status, by stitching together data available from various ONS sources.

However, it turns out that this reverse engineering from other data sources is not realistically possible given that there are fundamental discrepancies and inconsistencies between the various relevant ONS sources of data – a problem that has been highlighted in [8] and which we discuss further below. Of most concern is the observation that the ONS data may significantly underestimate the total population of unvaccinated people. **This means that, even when in future the ONS releases the age-categorized mortality data, it is likely that in many age categories the mortality rate for the**

unvaccinated will be overestimated (since the 'denominator' will be lower than it should be). This also means that the mortality rates presented in Table 1 are likely to be exaggerating the unvaccinated mortality rate (both for UMR and ASMR figures).

There are four relevant datasets that we considered, all of which are publicly available online:

- PHE/ONS data on age-adjusted mortality rates by vaccination status ('***PHE/ONS mortality***') [1].
- NIMS (National Immunisation Management Service), national flu and COVID-19 surveillance reports 01 July 2021 – Week 26 ('***NIMS vaccination survey'***) [3].
- ONS population estimates for the UK, England and Wales, Scotland and Northern Ireland: mid-2020 ('***ONS population survey'***) [4].
- Deaths registered weekly in England and Wales by age and sex from ONS. ('***ONS registered deaths'***) [5].

Discrepancies and inconsistencies in the data (which are further discussed in Appendix B) are identified as follows (bearing in mind that the PHE/ONS mortality data has been restricted to England only):

- According to the NIMS vaccination survey the population of England is 61,941,471, whereas the ONS population survey estimate is 56,550,138. The PHE/ONS mortality reports an even lower estimate still (see below). Inevitably, these differences lead to very different estimates of the crucial total number of people in each age category. The inaccuracy of NIMS population data is noted in [8] and to remedy it they argue that ONS population estimates should be preferred.
- Because the PHE/ONS mortality report omits children under the age of 10, we must restrict our analysis to the remaining population of England. According to the ONS population survey this sub-population totals 49,771,233. However, (for the reasons explained above) in the latest week of the PHE/ONS mortality report we considered (week 26 ending 2 July 2021) this sub-population was recorded as just 39,245,327 (this is the total of all unvaccinated plus all categories of vaccinated). Given that the NIMS vaccine survey estimates an even higher population than in the PHE/ONS mortality report, this means the PHE/ONS mortality report data is 'missing' at least 10 million people (49,771,233 - 39,245,327 = 10,525,906).
- The ONS registered deaths reports age stratified all-cause deaths for England and Wales combined, so the first assumption we must make in our analysis is to account for the fact that the ONS reports the total deaths in England and in Wales separately. For week 26 the ONS registered deaths lists a total of 8,808 all-cause deaths in people in England and Wales and 8,227 in England. Hence, we can apply the proportion (8,227/8,880) across each age group to estimate the expected deaths per age group and then remove the estimated under 10s from the England total. Alternatively, we could do the same adjustment by total population of each nation; this results in similar estimates. This results in an estimate of 8,192 deaths in the over 10s in England in week 26. However, because of the missing population millions in the PHE/ONS mortality report, they give a total of only 6,956 deaths for over 10s in England. Thus 1,236 deaths are unaccounted for.

How bad might the discrepancies be?

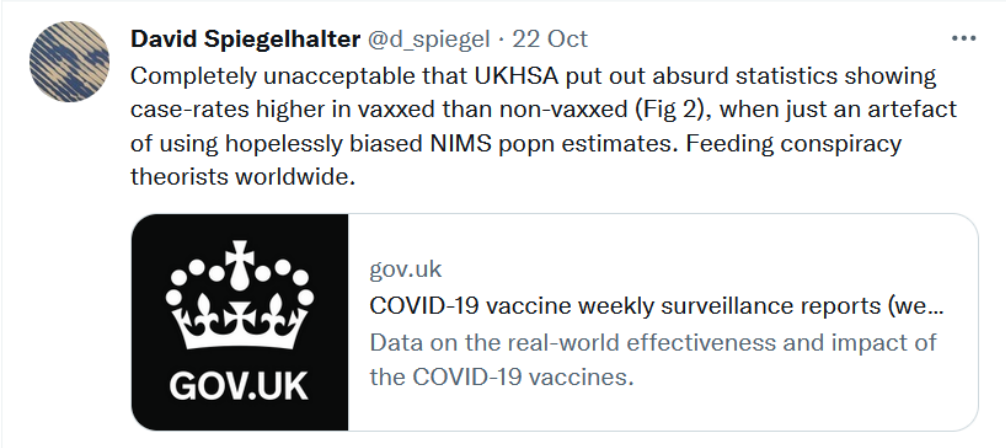

Figure 1 Tweet by David Spiegelhalter

The discrepancies between the NIMS and ONS population estimates were brought into sharp public focus on 22 October 2021 (several days after the first version of this report was published) when Prof Spiegelhalter posted the tweet in Figure 1. This was in response to the Week 42 PHE Vaccine Surveillance Report which showed that, for each age category above 30, Covid-19 infection rates were higher in the 2-dose vaccinated than in the unvaccinated.

Table 2 Table reproduced from PHE week 42 vaccine surveillance report (with added highlighted results showing higher infection rates among the 2 does vaccinated)

COVID-19 vaccine surveillance report – week 42

Table 2. COVID-19 cases by vaccination status between week 38 and week 41 2021

Cases reported by specimen date between week 38 and week 41 2021	Total	Unlinked*	Not vaccinated	Received one dose (1-20 days before specimen date)	Received one dose, ≥21 days before specimen date	Second dose ≥14 days before specimen date	Rates among persons vaccinated with 2 doses (per 100,000)	Rates among persons not vaccinated (per 100,000)
Under 18	397,882	24,292	351,148	10,698	11,001	743	314.1	3,013.6
18-29	62,885	7,512	20,902	758	8,404	25,309	462.1	615.4
30-39	92,257	7,346	21,726	636	6,545	56,004	956.7	751.1
40-49	130,904	7,297	13,022	293	3,800	106,492	1,731.3	772.9
50-59	88,020	4,790	5,399	80	1,632	76,119	1,075.3	528.6
60-69	45,155	2,614	1,872	24	617	40,028	704.1	347.1
70-79	27,360	1,559	658	12	215	24,916	537.9	267.6
≥80	11,907	854	382	7	215	10,449	406.8	304.1

Contrary to the implications in Prof. Spiegelhalter's tweet, it is not at all clear why the NIMS population estimate is any more 'biased' than the ONS estimate (which we believe drastically underestimates the proportion of unvaccinated). Moreover, no such concerns were expressed in previous weeks when rates amongst vaccinated were more favourable despite use of NIMS data for the population denominators. However, even though we are interested in mortality and not 'cases' getting the most accurate estimates of the number of people vaccinated and unvaccinated is equally critical for comparing rates between the two groups.

As we said we cannot reverse engineer the mortality estimates for each age category due to the unreliability of population denominators and death counts. To further explore this unreliability, we will attempt to derive the population estimates for each age category and the expected deaths from other ONS sources. Note that we are not claiming that these are reliable but using them to highlight the magnitude of potential errors that might be involved. We can do this using the NIMS vaccine survey, the ONS population survey and the ONS registered deaths data for week 26, ending 2 July 2021. We chose week 26 because: (i) it is the latest week for which data were available from the ONS at the time; (ii) it had the lowest Covid-19 mortality in any month up to that date in 2021 (there were only 109 Covid-19 deaths); and (iii) it is in summer and thus mortality data are generally less affected by influenza-like illnesses and other seasonal factors. Likewise, and perhaps even more importantly, compared to the period December 2020 – March 2021, by July the vaccination programme had vaccinated many millions of people over the age of 18, thus providing a huge and representative sample size on which to base any statistical or arithmetical estimates.

The analysis proceeds as follows:

1. Use the NIMS vaccination survey and the ONS 2020 population survey to estimate the population vaccinated and unvaccinated, in each age category using the ONS/PHE mortality report population of 39,245,327 people.
2. Sum over the age categories to 'reverse engineer' the total population in each of the vaccination categories, and then compare these to the ONS totals. Ideally, they should be "reasonably" close, but if not it then there are significant, perhaps worrying, differences between NIMS and the ONS mortality report.
3. Perform the steps above for the death counts.
4. Compare the results against ONS actuarial life tables for expected mortality.

Are the ONS underestimating the number of people unvaccinated?

The NIMS vaccine survey for week 26 has a total population of 61,941,461 of which 54,977,393 are listed as 10 years and over. From the NIMS vaccine survey, we can obtain the percentage by vaccination status for each age group shown in Table 3.

Because, for our reverse engineering of the figures, we are reliant on the PHE/ONS mortality report for total deaths by vaccination status, all our population sizes by age category must therefore be 'pro-rated' down to the population figure used therein, which is 39,245,327. If we apply these percentages to the ONS population size of 39,245,327 we get the distribution and totals shown in Table 4.

Note that in Table 3 the estimated totals are significantly different, but dramatically so for the unvaccinated category. Nearly 3 million of those we estimate to be classified as unvaccinated, using NIMS, are classified as two-dose vaccinated compared with the PHE/ONS survey. Appendix B further discusses the extent to which this discrepancy is due to either NIMS underestimating the number of vaccinated or ONS underestimating the proportion of unvaccinated.

Table 3 England population percentage by age category and vaccination status for week 26 (NIMS)

	NIMS Vaccination Survey Percentages		
Age	**Unvaccinated**	**1 dose**	**2 doses**
80 - 100	4.76%	2.13%	93.10%
75 - 79	4.59%	1.37%	94.04%
70 - 74	5.60%	1.44%	92.96%
65 - 69	7.84%	2.05%	90.11%
60 -64	9.84%	3.32%	86.84%
55 -59	11.83%	4.21%	83.96%
50 - 54	14.47%	5.01%	80.51%
45 - 49	19.63%	18.44%	61.93%
40 - 44	25.92%	27.36%	46.72%
35 - 39	33.05%	37.77%	29.18%
30 - 34	39.15%	37.77%	23.08%
25 - 29	44.43%	36.47%	19.09%
18 - 24	48.50%	36.11%	15.39%
10 - 17	98.62%	0.87%	0.51%

Table 4 England population by age category and vaccination status for week 26 (Estimated from NIMS versus PHE/ONS actual)

	PHE/ONS Survey Population Sizes estimated using NIMS survey percentages		
Age	**Unvaccinated**	**1 dose**	**2 doses**
80 - 100	95,143	42,640	1,860,177
75 - 79	68,126	20,295	1,395,722
70 - 74	114,869	29,542	1,906,242
65 - 69	161,773	42,369	1,859,099
60 -64	242,309	81,724	2,138,458
55 -59	344,018	122,541	2,442,592
50 - 54	436,365	151,169	2,427,187
45 - 49	559,952	525,964	1,766,329
40 - 44	762,316	804,650	1,373,909
35 - 39	1,062,460	1,214,192	938,243
30 - 34	1,325,233	1,278,374	781,135
25 - 29	1,406,056	1,154,221	604,162
18 - 24	1,808,472	1,346,375	573,908
10 - 17	3,922,069	34,554	20,394
Estimated Total	**12,309,162**	**6,848,610**	**20,087,556**
PHE/ONS Total	**9,531,364**	**6,404,395**	**23,309,568**
Difference	**2,777,798**	**444,215**	**-3,222,012**

Is the pattern of mortality what we might expect to see?

Next, we can use the death counts from the ONS registered deaths in week 26 to estimate the expected deaths for each age category in the unreleased PHE/ONS report. This is done using proportional allocation, which assumes the all-cause mortality rates are independent of vaccination status (and hence implicitly assuming vaccines have no impact on all-cause mortality). When the PHE/ONS release their data, we can test whether the pattern deviates significantly from this assumed independence. For now, all we can do is compare the total death counts given this is what PHE/ONS have released.

As we have said we have had to pro-rate the ONS registered deaths in week 26, to take account of differences between England & Wales and England. We can do this again for deaths in each age category and then use the ONS 2020 population survey to calculate the UMR for each age category. When we apply this UMR to the estimated populations in Table 4, we get the results shown in Table 5.

Table 5 England expected population percentage per age category and vaccination status all-cause deaths for week 26, using ONS 2021 death registration and ONS 2020 population data and Table 4 Estimated Populations

	All-cause deaths estimated in PHE/ONS using ONS deaths data and Table 3 Estimated Populations			UMR*
Age	Unvaccinated	1 dose	2 doses	
80 - 100	143	64	2,790	149.97
75 - 79	37	11	756	54.14
70 - 74	36	9	595	31.23
65 - 69	31	8	354	19.02
60 -64	34	12	301	14.08
55 -59	30	11	215	8.79
50 - 54	23	8	129	5.33
45 - 49	23	21	72	4.08
40 - 44	23	24	41	2.96
35 - 39	18	21	16	1.72
30 - 34	14	13	8	1.05
25 - 29	8	6	3	0.54
18 - 24	12	9	4	0.68
10 - 17	12	0	0	0.31
Expected Total	**444**	**218**	**5,284**	
PHE/ONS Total	**436**	**576**	**5,944**	
Percentage Ratio Actual/Expected	**98%**	**265%**	**112%**	

* Note that the UMR here is the same for all categories of vaccination

Notice that the Expected Total all-cause deaths (summing the totals of the three columns) is 5,945 whilst the PHE/ONS Total sums to 6,956. This is a significant difference. Likewise, when we compare the expected deaths versus actual deaths for each of the vaccination categories there is close alignment for the unvaccinated categories (444 versus 436), less so for the 2-dose vaccinated (5,284

versus 5,944) and much less so still for the single dose vaccinated (218 versus 576). The ratio of actual to expected is over 250% in the single dose vaccinated and 112% in the two-dose vaccinated.

We already noted earlier those 1,236 deaths of over-10s deaths in England during week 26 are unaccounted for (based on our estimate of 8,192 and the PHE/ONS mortality report number 6,956). It might be reasonable to expect that these occurred in the 'missing' 10 million.

Conclusions

All the caveats about confounders etc. that were discussed in our previous analyses and reports (notably in [7]) apply. However, the sample sizes here are sufficiently large for most of these to apply consistently across all classes of vaccination. We suspect that all confounders are likely to be present in all sub-populations to a similar degree. However, possible systemic biases might include:

- We are at the mercy of the grossly different and variable data and statistics available from the ONS in myriad form hence, needless to say, ***the reliability of our analysis is entirely reliant on the ONS data***.
- Vaccinated people may be more likely to have co-morbidities (which may partly explain higher mortality rates), although this is less relevant the lower the age and the higher the population in that age group that are vaccinated.

While our analysis is restricted to just the most recent week where death data by vaccination status is available (week 26), the previous four weeks show a similar pattern.

Our analysis has discovered that over 10 million people are missing from the PHE/ONS analysis and 1,236 deaths that occurred during week 26 are also missing. The vaccination status of this group is unknown. Furthermore, by reverse engineering the estimates from other ONS sources we have discovered that the PHE/ONS mortality report is underestimating the number of vaccinated people, from an approximate total of 39 million, by over 2 million people. Similarly, we believe the ONS may be underestimating the number of single dose vaccinated people by just over four hundred thousand. Given this, there is the possibility that as many as 22 million people, in week 26, were unvaccinated rather than the 9.5 million reported.

Our analysis clearly suggests that, when compared to ONS death figures from week 26, all-cause mortality (UMR) for vaccinated people, compared to unvaccinated people, is certainly higher in single dosed individuals and slightly higher in those who are double dosed.

Any analysis that relied solely on the PHE/ONS mortality data would be systematically biased by the fact that it would be conditioned on the available data, and how it is queried from available databases, rather than on the prevailing vaccination status of the population at large. In attempting to reverse engineer estimates of mortality by age category and vaccination status from the various relevant ONS datasets we found numerous discrepancies and inconsistencies which indicate that the PHE/ONS reports on vaccine effectiveness are grossly underestimating the number of unvaccinated people.

Although we have not subjected this data to statistical testing the potential implications of these results on the effects of vaccination on all-cause mortality, and by implication, the future of the vaccination programme is profound. Hence, if our estimates are inconsistent with the (unreleased) raw data, it is incumbent on the ONS to provide the raw data along with an explanation of why our estimates are wrong. We look forward to them releasing the data forthwith.

Acknowledgments

We would like to acknowledge Dr Clare Craig and Jonathan Engler for commenting on earlier drafts and Dr Vahe Nafilyan and Dr Charlotte Bermingham from the ONS for their advice and help.

References

[1] Public Health England/Office for National Statistics (PHE/ONS). Age-standardised mortality rates for deaths by vaccination status, England: deaths occurring between 2 January and 2 July 2021. https://www.ons.gov.uk/file?uri=%2fpeoplepopulationandcommunity%2fbirthsdeathsandmarriages%2fdeaths%2fdatasets%2fdeathsbyvaccinationstatusengland%2fdeathsoccurringbetween2januaryand2july2021/dataset.xlsx

[2] Revised European Standard Population 2013. https://webarchive.nationalarchives.gov.uk/ukgwa/20160106020035/http:/www.ons.gov.uk/ons/guide-method/user-guidance/health-and-life-events/revised-european-standard-population-2013--2013-esp-/index.html

[3] National Immunisation Management Service (NIMS) National flu and COVID-19 surveillance reports (PHE/ONS) 01 July 2021 – Week 26.

https://www.gov.uk/government/statistics/national-flu-and-covid-19-surveillance-reports

[4] ONS. Population estimates for the UK, England and Wales, Scotland and Northern Ireland: mid-2020. https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates/bulletins/annualmidyearpopulationestimates/mid2020

[5] Deaths registered weekly in England and Wales by age and sex: covid-19, 2021. ONS.

https://www.ons.gov.uk/datasets/weekly-deaths-age-sex/editions/covid-19/versions/51

[7] Fenton N.E., Neil M., McLachlan S., (2021) “Paradoxes in the reporting of Covid19 vaccine effectiveness: Why current studies (for or against vaccination) cannot be trusted and what we can do about it” http://dx.doi.org/10.13140/RG.2.2.32655.30886

[8] Barnes, O. and Burn-Murdoch J. “Covid response Hampered by population data glitches”, Financial Times, 11 October 2021.

[9] NHS England. Denominators for COVID-19 vaccination statistics. https://www.england.nhs.uk/statistics/wp-content/uploads/sites/2/2021/05/Denominators-for-COVID-19-vaccination-statistics.docx

[10] 2011 Census: Population Estimates by five-year age bands, and Household Estimates, for Local Authorities in the United Kingdom.

https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates/datasets/2011censuspopulationestimatesbyfiveyearagebandsandhouseholdestimatesforlocalauthoritiesintheunitedkingdom

Appendix A

Why all “all-cause mortality” is the most appropriate measure for overall risk-benefit analysis of Covid vaccines

- If Covid is as dangerous as claimed - and if the vaccine is as effective as claimed - we should by now have seen many more Covid related deaths among the unvaccinated than the vaccinated (in each age group).
- If the vaccine is as safe as claimed, then there should have been very few more deaths from causes unrelated to Covid among the vaccinated than the unvaccinated (in each age group).
- So, the count of all-cause deaths should be higher among the unvaccinated than the vaccinated (in each age group), confirming that the benefits of vaccination outweigh the risks.
- Counting all-cause deaths completely bypasses the problem of defining what constitutes a ‘Covid case’ or a ‘Covid related death’ (definitions which can be easily manipulated to fit different narratives).
- We define a person as ‘vaccinated’ if they have received at least one dose. As we are not interested in whether a person becomes a ‘Covid case’, any other definition is flawed as it will fail to acknowledge that adverse reactions (including death) from vaccines often occur shortly after vaccination.
- The fact that the US CDC (Centre for Disease Control) and other agencies now counts a person as ‘unvaccinated’ if they die within 14 days of the second dose, or after just one dose, might make some sense if we are interested only in the vaccine’s ability to stop infection. But in the context of death attribution, it makes no sense.

Appendix B - Under- and Over-reporting of Vaccinations

There are several ways that potential under- and over-reporting of COVID-19 vaccinations might occur.

The greatest potential for systematic errors in the estimation of people unvaccinated arises from the way the ONS reduces the total England population to a denominator of 39 million - represented by the dashed red line shown in Figure 1.

ONS staff explained to the authors of this paper how they begin with two datasets:

1. The population as reported from the *2011 Census*, from which they remove any individual verified as deceased.
2. The *General Practice Extraction Service* (GPES), from which they remove those who:
    a. are no longer registered with a GP clinic;
    b. no longer reside at the English postcode recorded on their Electronic Health Record (EHR), and;
    c. any records of patients reported as deceased or who were not present in England to have been counted in the 2011 census.

The population used in the PHE/ONS mortality report represents those individuals remaining across these datasets - effectively only a subset of each and almost twenty million people short of the estimated population of England for 2020.

Two issues arise from the conspicuous absence of these people. First, the vaccination status of these 'missing' is unknown. It cannot be automatically assumed that they are vaccinated, as the PHE/ONS statistics that report vaccinated figures are based on the reduced (red line) population. Second, the all-cause mortality figures used to develop the numerators includes everyone who has died during week 26, but the population denominator is missing a significant proportion of the population. If the majority of the missing individuals are, as we suspect, unvaccinated - their absence significantly inflates the UMR and ASMR for that group.

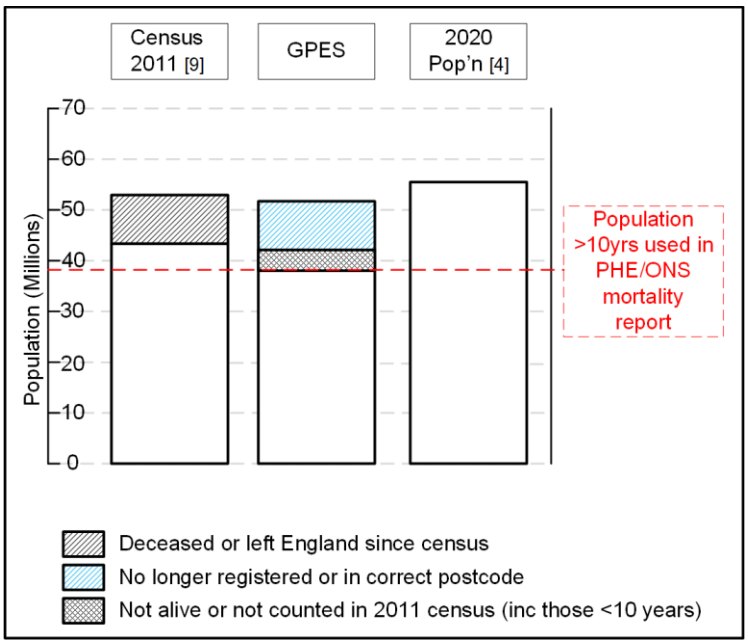

Figure 2: The ONS population conundrum

With the help from NHS Digital and NHS Trust Informatics team members we investigated potential pathways through the NHS recording keeping systems that might lead under and over-inflation, as describe in Figure 2.

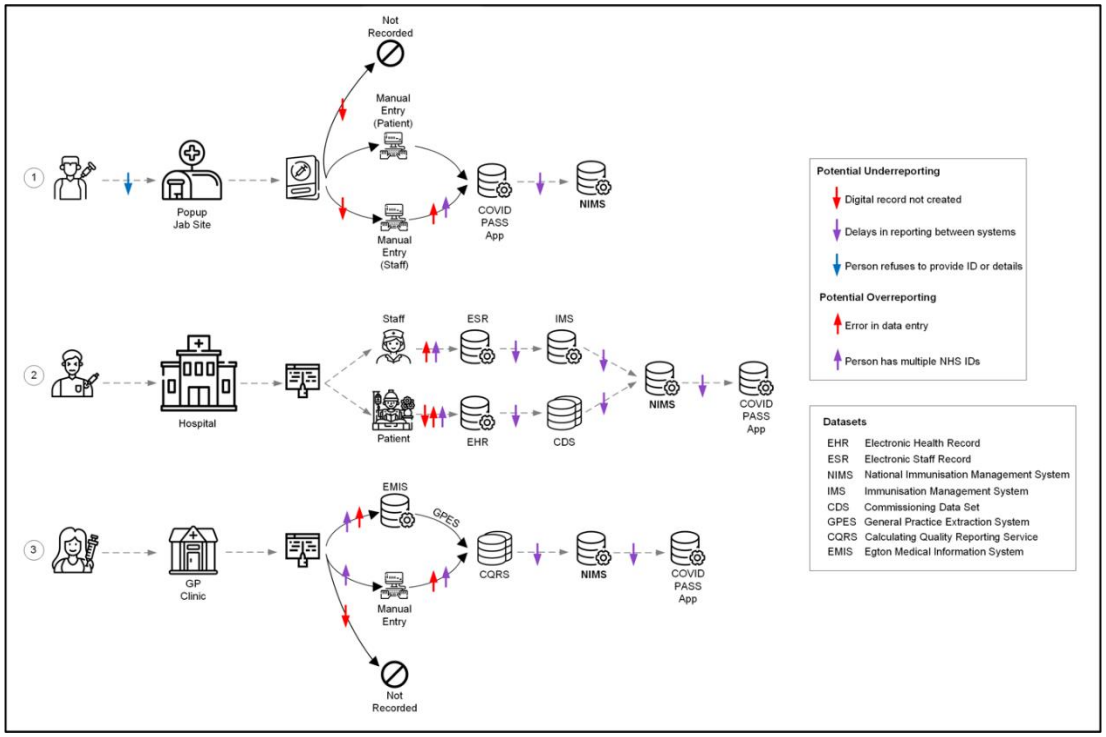

Figure 3: Sources for potential under- and over-reporting

Based on the weekly NHS vaccination site lists [1], Figure 2 shows three primary ways in which vaccination occurs:

1. Community-based *popup venue* or *vaccination centre* which have included tents in university quads, large public facilities such as racecourses and cricket grounds, shopping centres, council-owned car parks and town halls.
2. Hospital, either as a walk-in or during an in-patient stay.
3. The GP clinic where the individual is registered as a patient.

<u>Potential Underreporting of vaccinated:</u>

Underreporting may occur in all three pathways but is potentially more prevalent on the first. In particular:

- Vaccination cannot be refused where the individual declines to provide identification, an address or their immigration status [2]; while the total number of such individuals vaccinated may be recorded, they will not appear in any list of vaccinated.
- While the vaccinated individual is provided with a card that identifies the dose they received (first or second) and the batch number of the administered vaccine [3], it can depend on the site as to whether their vaccination status is reported on the NHS vaccine database (using either Outcomes4Health or NIVS) [4].
- At some sites, problems with IT result in staff having to record vaccinations manually using paper and pen [5]. There is obvious potential for error and missing records when manual entry must later be used to reconcile paper records with electronic records [6]. Any individual who declines to identify themselves cannot be appropriately recorded and reported to NIMS.

- The onus falls to the recipient to:
    - enter their vaccination details into the NHS App or website, or
    - take their vaccination card to their GP to have their record updated, and
    - to later remember to verify that their COVID PASS correctly reflects their status
- Some individuals may only need the vaccination card [3] to demonstrate their status to an employer and may therefore not need or bother to check whether their status has been reported and recorded in NIMS.
- As with any critical data-based infrastructure, security and complexity can introduce delay, from hours to weeks [6], in transferring new or updated information between different records systems. This can even actively prevent data transfer from occurring [7].

Potential Overreporting of vaccinated:

Overreporting can also arise on all three pathways. However, it is more likely to occur where an individual person receives their COVID-19 vaccinations at different sites. Overreporting may arise when:

- Individuals who do not identify themselves at popup venues or vaccination centres:
    - may not have been counted in the ONS census population count, or
    - may have resided outside England but get counted in England's vaccination figures.
- It is possible for vaccination to get recorded against the wrong NHS number [7]. If the vaccination recipient realises and shows their vaccination card to their GP, their vaccination status can be updated. However, unless the NHS number that the vaccination was erroneously recorded against it is known, or the individual who that NHS number belongs to becomes aware of the error and reports it, that other record may persist. As a result, it is possible for two different individuals' records to report as vaccinated from a single vaccination event. This can occur because of:
    - Errors in data entry.
    - The existence of multiple NHS records for the same individual [8], or
    - when one vaccination event is recorded against a married person's maiden name, and the second recorded against their married name - or vice versa [9].
- Confusion has arisen due to two individuals using the same NHS number [8], such as when an individual who is not entitled to free NHS maternity care uses the NHS number of a family member who is. If that individual is vaccinated during the antenatal period, this vaccination event will be recorded against the NHS number's true owner who will then be reported in the national counts as vaccinated when they are not.

In either case, whether under- or over-reporting, it can take many weeks and cause considerable frustration when individuals seek to correct errors in vaccination records once they have propagated between the myriad of databases, data systems and across organisations [10, 11] - and confusion over rules for the details that are recorded on vaccination certificates, vaccine passports and the degree of detail necessary when details are recorded from identity documents has only added to the confusion [12].

Up to 70% of medical records contain errors, with 23% being important or serious enough to affect future care potentially adversely [13], and many of these organisations have a notoriously poor record for ensuring all records pertaining to an error are corrected and 'cleaned up'. All of which give rise to potential under and over-reporting errors that we may not have realised in this paper.

References Appendix B

[1] https://www.england.nhs.uk/coronavirus/publication/vaccination-sites/

[2] https://www.london.gov.uk/coronavirus/covid-19-vaccine/getting-covid-vaccine-if-you-are-not-registered-gp

[3] https://bit.ly/3pdGfbu

[4] https://www.nhs.uk/conditions/coronavirus-covid-19/covid-pass/

[5] https://www.lbc.co.uk/news/it-crash-causes-clinicians-to-log-covid-jabs-with-pen-and-paper/

[6] https://digital.nhs.uk/coronavirus/vaccinations/covid-19-vaccination-record-queries

[7] https://www.bbc.co.uk/news/uk-scotland-58475922

[8] https://digital.nhs.uk/services/national-back-office-for-the-personal-demographics-service/data-quality-incidents

[9] https://www.telegraph.co.uk/news/2021/07/14/married-women-may-barred-flights-vaccine-certificates-maiden/

[10] https://www.eveningexpress.co.uk/fp/news/local/i-am-just-lost-aberdeen-womans-two-week-battle-to-change-name-on-covid-vaccine-certificate/

[11] https://www.england.nhs.uk/nhse-nhsi-privacy-notice/joint/how-to-access-your-personal-information-or-make-a-request-in-relation-to-other-rights/

[12] https://www.dailyrecord.co.uk/in-your-area/lanarkshire/lanarkshire-family-vaccine-passport-warning-24927385

[13] Pyper, C., Amery, J., Watson, M., & Crook, C. (2004). Patients' experiences when accessing their on-line electronic patient records in primary care. *British Journal of General Practice*, *54*(498), 38-43.