Gulf War Illness: a statistical analysis

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Assumed facts and problem statement

According to this article the coalition against Iraq in the first Gulf war of 1991 consisted of 39 nations with 28 providing a total of 670,000 troops.

For the purposes of my report I have been asked to assume that the effective number of nations in the alliance was 36 and that, of these, only five subjected their forces' personnel to an experimental immunisation programme. These nations were UK, USA, Canada, Australia and Denmark.

I have also been asked to assume that the average incidence of illness (the so-called 'Gulf war' illness) subsequently reported in the personnel of the five nations whose forces were vaccinated was 25-33% and these rates were consistent across those who had been in the battlefield front lines and those who had not. In contrast, the average incidence of illness subsequently reported in the personnel of the 31 nations whose forces were unvaccinated was consistent with the much lower general population rate for people of military age and health.

I have been asked to determine the probability that - by chance alone - all forces from the five vaccinated nations would suffer abnormally high rates of illness, while none of the 31 nations whose unvaccinated forces would suffer abnormally high rates.

There are two common ways of doing this ('classical' and 'Bayesian') and they produce different results because they are based on different statistical assumptions. However, either way, we conclude that there is no more than a 1 in 1.25 million chance that this pattern of normal and abnormal rates between the vaccinated and unvaccinated nations could happen without a causal explanation.

Classical solution

Because of the relatively small numbers involved, and the fact we have observed no abnormal instances among the unvaccinated nations, classical statistical tests like the Chi-squared test are not really suitable in this case.

Instead, the classic (but crude) approach to such a problem is to assume some appropriate estimate of the probability of an abnormally high rate of illness and to calculate the probability that the five vaccinated nations are all abnormal while the 31 unvaccinated nations are normal. However, it should be noted that ***any*** particular sequence of observations for the 36 nations is extremely unlikely (just as it is extremely unlikely to observe any particular sequence of heads and tails on tosses of a fair coin); so the interesting question is how much more unlikely is it to observe all of the 5 vaccinated nations as abnormal and the 31 unvaccinated normal compared to a sequence we would ‘expect’ to see if there was no difference (for example 1 abnormal out of 5 for the vaccinated and 6 abnormal out of 31 for the unvaccinated if the probability of an abnormally high rate is 20%). By analogy, how much more unlikely would it be to observe a sequence of 30 consecutive heads on the toss of a fair coin than a sequence with 15 heads and 15 tails?

In what follows I will assume that the probability of an abnormally high rate is 0.14 (14%) based on the fact that we have observed 5 out of 36 nations that are abnormal. This means that, through random chance alone, 14% of the nations would suffer an abnormally high rate. Then the probability a nation will ***not*** have an abnormally high rate is 0.86 (86%).

We assume not only that a nation will have an abnormally high rate by chance but also that the nations are ‘independent’ in the sense that whether one nation has an abnormally high rate does not affect whether any other nation does.

With these assumptions the probability that the five vaccinated nations each has an abnormally high rate is

0.14 x 0.14 x 0.14 x 0.14 x 0.14 = 0.000054

That means it is a very unlikely event (it is about a 1 in 19,000 chance).

The probability that none of the 31 unvaccinated nations has an abnormally high rate is:

0.86 x 0.86 x 0.86 … x 0.86 x 0.86 (0.86 to the power of 31) = 0.00932.

That is also unlikely (about 1 in 107 chance) albeit nothing like as unlikely as the five vaccinated nations all being abnormal.

Finally, to calculate the probability that the five unvaccinated nations all abnormal AND the 31 unvaccinated nations are normal we multiply the two probabilities:

0.000054 x 0.00932 = 0.0000005

This is about a 1 in 2 million chance.

That is extremely unlikely; to give a feel for how unlikely, it is about the same as the chances of you being struck by lightning sometime in the next 6 months, although not as unlikely as getting the winning ticket in a lottery where you choose 6 balls from 49 (about 1 in 14 million chance).

However, as stated above, it is important to compare this probability with the probability of observing the ‘expected’ sequence of about 1 abnormal out of 5 for the vaccinated and 4 abnormal out of 31 for the unvaccinated. As shown in Appendix 1 this probability is 0.0789 (about 1 in 13). That means it is about 160,000 times less likely to observe the 5 out of 5 and 0 out of 31 than it is to observe the ‘expected’ outcome if there was no difference in the abnormality rates for vaccinated and unvaccinated nations.

Note that the calculations are, of course dependent on the estimate of the probability of an abnormally high rate of illness. Other than the observed 5 out of 35 in the nations here, I do not have access to the data that would enable a more accurate estimate of this. However, whatever the value, the overall conclusion remains that we can reject with very high confidence the hypothesis that the observation of 5 out of 5 abnormal vaccinated nations and 0 out of 31 abnormal unvaccinated nations happened by chance. For example, if instead of 14%, the rate was 20% then the final probability is lower: 0.00000032 (about 1 in 3.2 million chance). And if the rate was 1% then the final probability is much lower still (about 1 in 14 billion chance) because the probability of just observing 5 out of 5 nations abnormal would be 0.01 to the power of 5 which is 1 in 10 billion.

The Bayesian solution

A far more rigorous way to handle this problem is the Bayesian approach where we 'learn' from the observed data the 'true' separate probabilities of abnormally high rate of illness for vaccinated and unvaccinated nations and then compute the probability that the rate really is no higher for vaccinated nations.

In this approach we make no prior assumptions about the true rate of abnormally high rate of illness for either vaccinated or unvaccinated nations other than it could be anything between 0 and 100% (we say that the probability is a 'uniform [0,1] distribution'). So, we start with the assumption that the (unknown) probabilities P1 (for vaccinated nations) and P2 (for unvaccinated nations) are anything between 0 and 1.

Using the same independence assumptions as above we calculate:

- The probability of observing 5 abnormally high rates in all 5 vaccinated nations is P1 to the power of 5. By Bayesian inference this enables us to compute the revised probability P1. Specifically, it is a distribution whose 95% confidence interval lies between 0.541 and 0.996 and whose median value is about 0.891. So, based on observing 5 out of 5 abnormal nations, we infer the 'true' probability is likely between 54.1% and 99.6%.
- The probability of observing 0 abnormal rates in all 31 unvaccinated nations is (1-P2) to the power of 31. By Bayesian inference this enables us to compute the revised probability P2. Specifically, it is a distribution whose 95% confidence interval lies between 0 and 0.109 and whose median value is about 0.021. So, based on observing 0 out of 31 normal nations we infer the 'true' probability is likely between 0% and 2.1%.

From the two revised probability distributions P1 and P2 we compute the probability that P1 is not higher than P2 is 0.000000802 which is about a 1 in 1.25 million chance.

The computational model providing these results (using the Agena.ai tool at simulation convergence 10^{-6}) is shown in Appendix 2.

Conclusion

There is no more than a 1 in 1.25 million chance that the pattern of normal and abnormal rates of illness observed between the vaccinated and unvaccinated nations could happen without a causal explanation. One possible causal explanation is, of course, that the high rates in the vaccinated nations were the result of the vaccination programme. My colleague Josh Guetzkow has alerted me this paper about Gulf War syndrome describing the theorized endogenous hypervitaminosis mechanism of vaccine injury.

Other possible causal explanations could be:

- Different combat roles of soldiers in the vaccinated and unvaccinated nations. For example, if all the soldiers in the vaccinated nations were in combat roles where they were subject to special environmental conditions and stresses. Indeed, the UK and USA provided the main land combat forces and were thus close to the Kuwaiti oil fires and possibly also exposed to depleted uranium, while unvaccinated nations like Syria were not on the front line. However, I understand that the abnormally high rates of disease were also observed in the non-combat personnel of the vaccinated nations. Moreover, the vaccinated Denmark had no troops on the front line or anywhere near oil fires or depleted uranium, while unvaccinated France were on the front lines.
- Different reporting practices between the vaccinated and unvaccinated nations. For example, if all the vaccinated nations followed up on soldiers' health more rigorously than any of the unvaccinated nations. However, this is unlikely given that the unvaccinated nations included "Western" nations like France, Italy, Spain, Belgium and Norway whose reporting practices would surely be no less rigorous than those of the 5 vaccinated nations.

Very different sizes of forces between the vaccinated and unvaccinated nations would also compromise the above analysis. For example, if there were only tiny-sized forces among the unvaccinated nations then the significance of the conclusion would be reduced. However, only 4 of the unvaccinated nations contributed less than 300 soldiers.

Statement of truth

I confirm that insofar as the facts stated in my report are within my own knowledge I have made clear which they are and I believe them to be true, and that the opinions I have expressed represent my true and complete professional opinion.

Norman Fenton 5 October 2023

Appendix 1: The probability of observing the ‘expected number of abnormal nations

With the same assumptions as above (i.e. 14% probability a nation is abnormal), the ‘expected’ number of abnormal nations out of 5 vaccinated would be 0 or 1 (let’s say 1) and the ‘expected’ number of abnormal nations out of 31 unvaccinated would be 4.

By the Binomial Theorem the probability of observing 1 abnormal out of 5 for the vaccinated nations is 0.383

(that is 5 times 0.14 x 0.86 x 0.86 x 0.86 x 0.86 since there are 5 combination of 1 from 5)

By the Binomial Theorem the probability of observing some 4 out of 31 abnormal for the unvaccinated nations is 0.206

(that is 31,465 times (0.14 x 0.14 x 0.14 x 0.14) x $(0.86)^{27}$ since there are 31,465 different combinations of 4 nations from 31)

So, the probability of observing 1 abnormal out of 5 for the vaccinated ***and*** 4 abnormal out of 31 for the unvaccinated is

0.383 x 0.206 = 0.0789

That is a 1 in 12.67 chance. Since there was only a 1 in 2 million chance of observing 5 out of 5 abnormal for the vaccinated and 0 out of 31 we conclude that this probability is about 160,000 times less likely than observing an ‘expected’ outcome if there was no difference in the abnormality rates for vaccinated and unvaccinated nations.

Appendix 2: Bayesian results