Bayes Theorem In general we have, $$ \Pr(H|E) = \dfrac{\Pr(E|H)\Pr(H)}{\sum\Pr(E)} $$ For the case of two events, E and $\neg E$ $$ \Pr(H|E) = \dfrac{\Pr(E|H)\Pr(H)}{\Pr(E|H)\Pr(H) + \Pr(E| \neg H)\Pr(\neg H)} $$ **Explanation:** We're interested in the probability that that something happened, H, given that we have evidence, E, that it happened. So, we're interested in $\Pr(H|E)$. However, we also need an estimates of $\Pr(H)$, $\Pr(E|H)$ and $Pr(E|\neg H)$. **Example:** For a totally made up example, say H is the case that you have Covid-19, and E is a negative test result. So we want to know the probability that we have Covid-19, given that we've tested negative. Let's assume that you've been on a flight, but you wore a mask the whole time, so $\Pr(H) = 0.3$. You *probably* don't have Covid-19, but maybe you do. The probability that you test negative, given that you are negative is $$ \Pr(E|\neg H) = 0.985 $$ The probability that you test negative, given that you are positive is $$ \Pr(E|H) = 0.015 $$ Here is the confusion matrix for Covid-19 take home tests. ************************************* * Actual * * Pos. Neg. * * +---------+---------+ * * | 84.6% | 15.4% | * * Pos. | | | * * | TP | FP | * * TEST +---------+---------+ * * | 1.5% | 98.5% | * * Neg. | | | * * | FN | TN | * * +---------+---------+ * ************************************* Then we have, $$ \Pr(E|H)\Pr(H) = (0.015)(0.3) = 0.0045 $$ and $$ \Pr(E|\neg H) = (0.985)(0.7) = 0.6895 $$ Therefore, $$ \Pr(H|E) = \dfrac{0.0045}{0.0045 + 0.6895} = 0.00648 $$ There's a very low chance you have Covid-19, given that you test negative, taking into account that there's a decent chance, 30%, that you were exposed. The grat thing about Bayes' Theorem is that you can provide additional information, like what you believe your exposure was over your trip.