For each population i, we start with a test tube of volume Vt (known) containing Nt,i (unknown) cells. From this, a sample of volume Vst (known) is taken and diluted Dt-fold (known): this is then plated and the colonies counted to give xt,i (known). From all this, we see that xst,i is drawn from a Binomial distribution:

.

Note that Nt,i are the sole unknowns here, and so we estimate them following (Blumenthal and Dahiya, 1981; Feldman and Fox, 1968) TODO

Note also that plating and counting more than once could reduce the uncertainty in Nt,i, but that this is often impractical.

Another sample, volume V0 (known), is taken from each test tube and transferred into a flask of volume Vf (known). The numbers of cells in this sample will be . The uncertainty in N0,i is TODO current script skips this step, assumes that whole tube is poured into flask

This is then left to incubate for time T and the number of cells of each population is assumed to grow exponentially with rate ri (unknown) to and so

.

A sample of the flask is then taken, plated and counted as before to estimate the xf,i. We denote the sample volume to be Vsf, the dilution Df, and the colony counts as xsf,I:

.

We then estimate Nf,i and the uncertainty in our estimate in the same manner as for the Nt,i.

The uncertainty in the growth rates ri is then TODO (Katz et al., 1978) and papers citing it, but uncertainty is in p rather than in n

Once we have estimates of N0,i and Nf,i, together with estimates of their uncertainty, we

|  |  |
| --- | --- |
| **Symbol** | **Description** |
| \*0 | Index for time 0 in the flask |
| \*f | Index for the final time in the flask |
| \*s | Index for a sample |
| \*t | Index for the test tube |
| D\* | Dilution factor |
| N\*,i | Unknown number of cells of population i |
| ri | Growth rate of population i |
| V\* | Volume of a tube, flask, or sample |
| x\*,i | Number of colonies of population i counted on a plate |

**Table 1.** Descriptions of symbols used.

## References

Blumenthal, S. and Dahiya, R. C. (1981) ‘Estimating the Binomial Parameter n’, *Journal of the American Statistical Association*, vol. 76, no. 376, pp. 903–909 [Online]. DOI: 10.2307/2287586.

Feldman, D. and Fox, M. (1968) ‘Estimation of the Parameter n in the Binomial Distribution’, *Journal of the American Statistical Association*, vol. 63, no. 321, pp. 150–158 [Online]. DOI: 10.1080/01621459.1968.11009230.

Katz, D., Baptista, J., Azen, S. P. and Pike, M. C. (1978) ‘Obtaining confidence intervals for the risk ratio in cohort studies’, *Biometrics*, vol. 34, no. 3, pp. 469–474 [Online]. DOI: 10.2307/2530610.