Estimation of the probability of contact for CAR T cells and target cells in cytotoxic assays in vitro

The co-culture experiments were performed in 96 well tissue culture plates where each well has a volume $V (= 0.2 \text{ mL})$. For an assay with $10,000 \ (n_{\text{tcell}})$ CD8+ T cells and $20,000 \ (= n_{\text{target}})$ target cells we estimate the probability of a CD8+ T cell having at least one target cell in contact with it. We divide the volume $V$ in cubic chambers of volume $v = (d_{\text{tumor}}+d_{\text{tcell}})^3$, where $d_{\text{tumor}} (= 6 \mu m)$ and $d_{\text{cell}} (= 17 \mu m)$ are the diameters of a K562 cell (Henslee et al., 2011) and a CD8+ T cell, respectively. Thus, the culture well can be divided into $V/v \approx 1.6 \times 10^7$ small chambers and we assume the target and the CD8+ T cells are distributed uniformly and randomly in the culture well. The probability for choosing a target cell or a CD8+ T cells is $p_{\text{target}} = n_{\text{target}}/ (V/v) \approx 1.25 \times 10^{-3}$, or, $p_{\text{tcell}} = n_{\text{tcell}}/ (V/v) = 0.625 \times 10^{-3}$. Now we can estimate what is the probability $(=p_{\text{contact}}(n))$ that a T cell will share a small chamber with $n$ number of target cells which will be given by,

$$p_{\text{contact}}(n) = \binom{n_{\text{target}}}{n} (p_{\text{tcell}})^n (1-p_{\text{tcell}})^{n_{\text{target}}-n}$$

Thus, the probability that a CD8+ T cell does not reside in the same chamber with a target cell is $p_{\text{contact}}(n = 0) = (1 - p_{\text{tcell}})^{n_{\text{target}}} \approx 1.9 \times 10^{-3}$. Thus, 99.8% CD8+ T cells are in contact with target cells in the culture well. Variation of $p_{\text{contact}}(n)$ with $n$ is shown below.