**S1 Table. Model quality as assessed by AIC.**

|  |  |  |
| --- | --- | --- |
| **ID** | **Model** | **Δ AIC** |
| A | $$k\_{0}+ε\_{R}$$ | 0 |
| B | $$k\_{0}+ε\_{D}+ε\_{R}$$ | 1,123.24 |
| C | $$k\_{0}+a\_{v}+ε\_{R}$$ | 1,820.08 |
| D | $$k\_{0}+a\_{v}+ε\_{D}+ε\_{R}$$ | 2,059.26 |
| E | $$k\_{0}+s\_{r}+ε\_{R}$$ | 2,298.44 |
| F | $$k\_{0}+s\_{r}+ε\_{D}+ε\_{R}$$ | 3,487.73 |
| G | $$k\_{0}+s\_{r}+a\_{v}+ε\_{R}$$ | 4,082.94 |
| H | $$k\_{0}+s\_{r}+a\_{v}+ε\_{D}+ε\_{R}$$ | 4,641.86 |
| I | $$k\_{0}+\sum\_{i=1}^{62}m\_{i}δ\_{i}(r,v)+s\_{r}+a\_{v}+ε\_{D}+ε\_{R}$$ | 31,610.46 |
| J | $$k\_{0}+\sum\_{j=1}^{7}k\_{j}α\_{j}\left(r,v\right)+\sum\_{i=1}^{62}m\_{i}δ\_{i}(r,v)+s\_{r}+a\_{v}+ε\_{D}+ε\_{R}$$ | 34,525.13 |
| K | $$k\_{0}+s\_{r}+a\_{v}+γ\_{rv}+ε\_{D}+ε\_{R}$$ | 40,814.98 |
| L | $$k\_{0}+\sum\_{l=1}^{11}k\_{l}^{'}α\_{l}^{'}\left(r,v\right)+\sum\_{j=1}^{7}k\_{j}α\_{j}\left(r,v\right)+s\_{r}+a\_{v}+ε\_{D}+ε\_{R}$$ | 33,265.94 |
| M | $$k\_{0}+k\_{130}^{'}α\_{130}^{'}\left(r,v\right)+k\_{141}α\_{141}\left(r,v\right)+s\_{r}+a\_{v}+ε\_{D}+ε\_{R}$$ | 26,957.81 |

Models are shown alongside their Δ AIC, the improvement in AIC relative to a null, intercept model (model A). Model terms are consistent with notation used in Equations 1-7 and are described in full in S2 Table. Models A-H include every combination of base terms introduced in Equation 1. Relative AIC scores led to H being strongly preferred and other combinations were therefore discounted. Models I and J contain 62 branch terms identified using Equation 2. Model J also includes terms for seven substitutions identified using Equation 3. Model K generates a fitted value for every observed combination of reference virus and test virus and corresponds to Equation 7. Models L and M include only substitution terms to explain antigenic differences and no branch terms. Model L includes all 18 identified substitutions (7 identified using Equation 3 and 11 identified using Equation 4). Model M contains terms for the substitutions of highest antigenic impact (K141E and ΔK130) only.