

## Supplementary Figure Legends

**Supplementary Figure 1. Epitope maps of monoclonal antibodies on A(H1N1)pdm09 HA (H1pdm09).** Binding affinities of mAbs for wild type (WT) and each mutant of the H1pdm09 panel were determined by BLI and are presented as endpoint responses. “\*” indicates mutations with  $\geq 50\%$  reduction in binding activity. “▲” indicates mutations with faster off-rate and  $< 50\%$  reduction in binding activity.

**Supplementary Figure 2. Epitope map of mAb F045-092 on A(H3N2) A/Hong Kong/4801/2014 HA (HK4801 H3).** Binding affinities of mAb F045-092 for WT and each mutant of the HK4801 H3 panel were determined by BLI and presented as endpoint response. “\*” indicates mutations with  $\geq 50\%$  reduction in binding activity. “▲” indicates mutations with faster off-rate and  $< 50\%$  reduction in binding activity.

**Supplementary Figure 3. Neuraminidase activities of recNAs of the A(H7N9) A/Shanghai/2/2013 (SH2 N9) panel.** Neuraminidase activities of WT and mutants of the SH2 N9 panel were determined by MUNANA assay following procedures as described previously (Yang et al., 2015). The results were presented as percentage of the wild type N9 neuraminidase activity.