<u>How Mathematics Makes Antibodies a Lens into the Immune System</u>

Have you wondered why different COVID-19 vaccines were recommended, why multiple doses were needed, or whether more will be needed in future? These are challenging questions. Though previous research has uncovered how vaccination stimulates fundamental components of the immune system, including B cells and plasma cell, to produce antibodies and protect you, establishing the exact effects of vaccination requires a lot of data. Data on plasma cells and B cells are difficult to collect. They reside in bone marrow and lymph nodes, requiring intensive surgery to reach.

Antibodies, however, are easily collected through blood samples. Hence, data can be collected from many people and observing how antibody levels change over time is easy. We use statistical methods to apply mathematical equations to antibody data and extract information about the underlying processes of plasma cells.

Through our analysis we can explain differences in antibody levels between age groups, the number of doses, and the type of vaccine. We find that younger people double dosed with Pfizer have the highest short-term antibody levels, due to their short-lived plasma cells having the greatest capacity to produce antibody. However, we also find that AstraZeneca induces long-lived plasma cells and therefore life-long antibodies, while Pfizer does not.

Using COVID-19 as a case study, we have demonstrated that mathematical tools can quickly and easily provide novel insights into fundamental processes of the immune system, without invasive procedures. Greater application of mathematics could revolutionise our understanding of immune responses to vaccination.