**In Vitro Fertilisation (IVF)**

What is IVF?
The primary treatment for infertility, where an egg cell is fertilised outside the body and transferred to the womb. Over 8 million IVF babies have been born worldwide. The UK fertility market is worth £320 million, growing 7.6% per annum.

Why is this important?
More successful IVF drives growth in the UK fertility market. Demand for IVF outweighs supply, so there are long wait lists. Social impact: family planning, population growth, underprivileged groups.

**Non-invasive egg assessment**

Assessing egg health allows faster embryo transfer. Earlier transfer → shorter treatment time → higher patient turnover. However, current methods to assess health destroy the embryo.

We have time series images of eggs, but current analysis is poorly suited to cytoplasmic motion (advection-diffusion) and the microscope type (phase contrast).

Can we find a non-invasive method of egg health assessment?

We derive a new formula for Differential Dynamic Microscopy (DDM), which extracts advection-diffusion speed in phase contrast data.

\[ D_I = A(q)\left(1 - J_0(\xi) + e^{-\alpha} \left( J_0(R+) + J_0(R-) - J_0(A) \right) \right) \]

\[ R_\pm = \sqrt{\lambda^2 + \xi^2 \pm 2\lambda\xi \cos(\phi)} \]

These speeds can be used to statistically quantify egg health.

**Optimising embryo freezing**

Vitrification (freezing) preserves embryos using liquid nitrogen for rapid cooling. Faster cooling correlates with better survival rates. However, vitrification protocol is open to interpretation. Clinicians can freeze variable numbers of embryos together, in different arrangements.

Is there an optimal setup for vitrification?

Constructing 3D computational models, we predict heat transfer during vitrification to safely “experiment” with different protocol.

Arrangement and number does not affect cooling rates. More flexible clinical protocol.

**Selecting the best embryo**

During vitrification, cells contract and lose water. When thawed, they expand back to normal.

Incubators take images every 5 minutes of this process. Embryologists can spot dead or damaged embryos but cannot say whether an embryo will be successful.

Can we predict whether an embryo is viable for IVF based on the way it expands?

Machine learning measures the size of features of the embryo.

Embryos with non-linear growth patterns are less likely to succeed.

Up to 3% pregnancy improvement.