Nasal Drug Deposition Studies for the Pharmaceutical Industry

Objectives
Investigate the influence of nasal spray device parameters on drug deposition in the nasal cavity.

Introduction
The drug delivery market is worth billions of dollars and the potential for growth in this sector is extensive due to its advantages including improved patient compliance (elimination of needles), avoidance of first-pass metabolism and rapid onset of action.

Effective drug delivery requires knowledge of:
- airflow field in the nasal cavity
- particle-air interactions
- deposition mechanisms on the nasal cavity walls.

Numerical Setup
Four different models were used and by grid independence, the model containing 586,000 cells was used.

Boundary Conditions
- k-ε realizable, steady.
- Discrete Random Walk stochastic model used to track particles.
- 10μm to 30μm particles used
- Airflow rates = 10L/min to 40L/min

Drug Particle Injection Setup
Particles were released into the nasal cavity, under the assumption of the atomisation of drug particles from an internal pressure-swirl atomiser in the nasal spray nozzle.

Results
- Particle Trajectories and Deposition Sites

Particles were released from an approximate natural location at different insertion angles.

- 0 degree insertion angle
- 80 degree insertion angle

50μm - 90 degrees
10μm - 0 degrees

- The horizontal insertion angle (90deg.) for 50μm provides later deposition, where they finally deposit at the back of the nasopharyngeal region.
- 10μm particles deposit more readily in the middle turbinate regions of the nasal cavity but also display the undesirable delivery of particles beyond the nasopharynx leading to deposition in the lungs.

Conclusion
Implication for Nasal Spray Design
- Horizontally aligned injections require innovative designs enabling such an extreme insertion angle.
- Larger particles aligned horizontally were drawn into the streamlines along the floor of the nasal cavity and not able to reach the middle and superior turbinate regions.
- A possible solution to this may be to induce greater swirl to generate a vortex enabling the particles to reach the middle and superior regions of the nasal cavity.

Improvements
- Using further advanced turbulence models.
- Quantify typical locations from users in relation to the nasal cavity and apply these locations for study.
- Need to capture in detail the spray dynamics of particle formation, secondary breakup, coalescence, air entrainment.
- Porosity function—nasal hairs.