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Mathematical modelling of foot-and-mouth disease virus infection of bovine epithelial cells.

Foot-and-mouth disease (FMD) is a highly infectious animal disease that affects cloven hoofed animals (including cattle, sheep and pigs) and causes acute clinical signs such as vesicular lesions in the foot and mouth, lameness, fever and pain; in more severe cases it can lead to death of young livestock. In areas where FMD is endemic, it is considered to be the main threat to animal health and economic development, while an outbreak of FMD in 2001 in the United Kingdom, a disease-free country, resulted in 6.5 million animals being slaughtered and losses of £6 billion. Persistence of FMD virus (FMDV) occurs in previously infected but apparently recovered animals, in the pharyngeal area, specifically in the dorsal soft palate [1]. These carrier animals are a possible source of virus transmission, and potentially facilitate viral mutations. In addition to the persistence of FMDV, the virus appears not to cause lysis in the dorsal soft palate, even though lesions appears on the tongue and coronary band.

Presented in this talk is a mathematical model which aims to test the hypothesis that it is the different structure of epithelial cells, rather than the intrinsic properties of the tongue and dorsal soft palate that determines the extent of FMDV lysis. A simple ODE compartmental model of Schley et al (2010) [2] considered static live cells and indicated that the dimensions of the epithelial tissues in the tongue and dorsal soft palate are important for cell lysis and FMDV persistence. Here, this has been extended to a spatially explicit system of partial differential equations that describes the viral dynamics in the epithelial layers of both tissue types. The model

accounts for the movement of cells through growth, and includes heterogeneity of the cell layers which form the epithelium. New experimental data, required to fit the model, has been collected and applied, together with existing results from the literature. We will present numerical results from a limit of the model, relevant on the timescale of the early infection stages before the immune response becomes effective and discuss key insights. A full active system which accounts for the formation of lesions is work in progress.

References

[1] S. Alexandersen, Z. Zhang, A. I. Donaldson, and A. J. M. Garland, *The patho- genesis and diagnosis of foot-and-mouth disease.* Journal of Comparative Pathology **129** 1–36.

[2] D. Schley, J. Ward, and Z. Zhang, *Modelling foot-and-mouth disease virus dynamics in oral epithelium to help identify the determinants of lysis.* Bulletin of Mathematical Biology http://dx.doi.org/10.1007/s11538-010-9576-6 11–26.