Description for a problem studied at the UK Mathematics-in-Medicine Study Group Southampton 2007
< http://www.maths-in-medicine.org/uk/2007/decompression-sickness/ >

Parameter estimation in decompression sickness

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Ambient pressure at sea level is approximately one bar. For every 10 metres a diver descends in the sea, the pressure she is exposed to increases by one bar. During exposure to raised pressure, nitrogen in a diver's breathing air is carried to their body tissues in the blood where it diffuses into the tissues. The rate at which this diffusion takes place decreases exponentially as the tissue nitrogen tension approaches that of the arterial blood. At equilibrium, the diver's body tissues are said to be saturated with nitrogen. On rapid decompression to a lower pressure, some tissues will be supersaturated with nitrogen relative to the ambient pressure. This supersaturation can drive the formation of bubbles in the body which may cause numerous symptoms, including joint pain (the 'bends'), paralysis and death. Decompression sickness (DCS), as this collection of symptoms is known, is a limiting factor in escape from a disabled submarine. Our work is aimed at increasing survival in this scenario.

The physical and physiological processes involved in the aetiology of decompression sickness (DCS) are not well understood. Many mechanistic model structures have been proposed for use in the prediction/avoidance of DCS; many of the parameters of these models have not been measured directly. Large sets of pressure exposure data are available where the occurrence of DCS is expressed as a binary outcome. Several investigators have estimated model parameter values using the method of maximum likelihood on selected data sets. The complexity of the models is limited by the relative sparseness of DCS events within the data sets — an increase in the number of parameters is only accepted for a significant increase in the maximum likelihood. Evidence from biological and physical studies suggests important elements of the disease process and bounds on the values of parameters believed to

relate to certain relevant physiological processes that could be included in our models; although the volume of decompression data may not directly lend support to this through maximum likelihood testing.

It has been suggested to us that the application of Bayesian ideology might allow us to include this type of information in our models — are there methods that we should be following to achieve this? The data we employ comes from many different trials which were conducted with different aims — should we be applying Bayesian techniques when we use this data in our parameter estimation?