Recently, many Bayesian methods have been developed for dose-finding when simultaneously modeling both toxicity and efficacy outcomes in a blended phase I/II fashion. A further challenge arises when all the true efficacy data cannot be obtained quickly after the treatment, so that surrogate markers are instead used (e.g., in cancer trials). In this thesis, we first propose a framework to jointly model the probabilities of toxicity, efficacy and surrogate efficacy given a particular dose. The resulting trivariate algorithm utilizes all the available data at any given time point, and can flexibly stop the trial early for either toxicity or efficacy. Our simulation studies demonstrate our proposed method can successfully improve dosage targeting efficiency and guard against excess toxicity over a variety of true model settings and degrees of surrogacy.

Second, we offer a brief catalog of more flexible semiparametric and nonparametric monotone link functions to model the marginal probability of efficacy based on our proposed trivariate binary model. We show via simulation that our flexible link methods can outperform standard parametric CRM approaches in terms of both the probability of correct dose selection and the proportion of patients treated at that dose.

Finally, frequentist sample size determination for binary outcome data usually requires initial guesses of the event probabilities, which may lead to a poor estimate of the necessary sample size. We propose a new two-stage Bayesian design with sample size reestimation at the interim stage. Our design inherits the properties of good interpretation and easy implementation, generalizing an earlier method to a two-sample setting, and using a fully Bayesian predictive approach to reduce an overly large initial sample size when necessary. Moreover, our design can be extended to allow patient level covariates via logistic regression, now adjusting sample size within each subgroup based on interim analyses. We illustrate the benefits of this approach with a design in non-Hodgkin lymphoma with a simple binary covariate (patient gender), offering an initial step toward within-trial personalized medicine.