Summary

In this thesis we address a number of challenging problems related to health care logistics. These problems are motivated by hospital managers who collaborated in the research, and the results are applied at their hospitals. The general results and solution approaches presented in this thesis are also valid in other hospital settings.

To position the research we review quantitative health care literature to examine the extent to which models encompass multiple hospital departments and account for department-to-department interactions. We provide a general overview of the relationships which exist between major hospital departments and describe how these relationships are accounted for by researchers. Our review of literature found that researchers often confine models to single departments due to system complexity and the uncertain nature of patient flows (Chapter 2). Using and developing techniques from queueing theory, mathematical programming, and simulation, we demonstrate how these characteristics can be coped with by solving multiple strategic, tactical, and operational problems faced by our partner hospitals.

Using queueing theory we model the complex and uncertain relationship between capacity, case mix and patient mix. With parameters provided by this queueing model, we formulate a combinatorial optimization problem to maximize the hospital's remuneration under a fee-for-service financing system. We thus provide a methodology for optimizing strategic capacity and case mix planning decisions. Ex-

act solutions can be found with integer linear program solvers and approximate solutions with dynamic programming (Chapter 3).

A second strategic problem is deciding whether (and to what extent) to pool resources within hospitals. Due to the uncertainty of patient arrivals and the economies of scale found in the pooled departments, access time will typically be worse in unpooled departments. However, if the service time is sufficiently lower in the unpooled departments, due to more focused care, the opposite is true. Using queueing theory we derive general results stating the extent to which focused care must decrease service time in an unpooled department in order to compensate for the lack of economies of scale. The main characteristics influencing economies of scale losses are clinic load, proportional size of the patient groups, resource divisions and appointment length variability (Chapter 4).

At a tactical level, physicians and hospital managers must decide how many patients a single physician can effectively be accountable for (i.e. panel size). We formalize an extension to existing models allowing the panel size to be a random variable which accounts for the uncertainty in patient flows. Using queueing theory we provide general results related to capacity planning and provide strategies for reaching and maintaining a panel size that meets certain performance criteria (Chapter 5).

Developing a surgical schedule that does not overwhelm inpatient wards is a complex problem, given that surgery durations and patient length of stays are uncertain. Using applied probability, we develop a solution approach for the tactical level master surgical scheduling problem. Our approach, used to develop a new master surgical schedule at the collaborating hospital, is readily repeatable and has been used at multiple Dutch hospitals. Using a case study, and by comparing predicted ward occupancies with post-implementation ward occupancies, we validated the approach (Chapter 6).

An operational level problem faced by many pharmacies is deciding when to prepare medication. This problem is complex because medications are expensive and have a limited shelf life, and uncertain, because patient no-shows are common in hospitals. Analyzing this problem for a chemotherapy pharmacy, our case study predicted waiting times could be decreased by 30 minutes while only increasing pharmacy costs by 1-2%. The research led to analytic approximations (validated with discrete event simulation) usefull for predicting patient waiting times and costs in any pharmacy. Our analysis in Chapter 7 led to a new pharmacy policy which has been implemented at the collaborating hospital.