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Estimating the Acceptable Time to Cholecystectomy in Patients with Gallstone Pancreatitis using Bayesian Conjugate and Hierarchical Models

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Extended Abstract

Acute pancreatitis represents a spectrum of disease, with cases typically classified as mild, moderate or severe. Approximately two-thirds of patients experience a mild disease course, with a mortality rate of around 1%. The remaining one-third have a more complicated course, which is associated with a significantly higher mortality risk (up to 50% in cases complicated by infected necrosis or multi-organ failure) [1].

Gallstones are the underlying cause in approximately 40–70% of acute pancreatitis cases[2]. Patients who experience gallstone pancreatitis are at risk of recurrence if a cholecystectomy is not performed. The mortality risk in subsequent episodes is unpredictable.

Same-admission cholecystectomy is currently considered best practice for patients with mild gallstone pancreatitis. This recommendation is supported by data showing a 10–30% risk of recurrence when surgery is delayed, without increased morbidity from early intervention[3]. However, this ideal is not always achievable, particularly in resource-limited settings. Several barriers —including the need for common bile duct clearance, logistical constraints, financial limitations, and disruptions such as the COVID-19 pandemic—frequently delay definitive surgery.

Existing estimates for recurrence risk and timing are largely derived from simple count-based analyses[4], [5], with uncertainty typically reported as ranges across small individual studies. These studies suffer from small sample sizes and, consequently, high intrinsic variance.

The data-generative process can be better modeled, and uncertainty better estimated, using Bayesian principles. We apply a conjugate beta-binomial model to estimate recurrence risk, using a prior based on established international data. For time-to-recurrence estimation, we use a conjugate gamma-Poisson model with a non-informative prior. These distributions support the construction of a hierarchical Bayesian model that allows posterior uncertainty quantification for an individual patient's risk of recurrence per week of surgical delay. This framework can better inform the planning of interval investigations, interventions, and elective surgery.

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