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How inpatient boarding impacts ED performance: A queueing analysis

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This article uses a Markov-modulated fluid queue approach to gain insights into the effect of boarding patients on emergency department performance. Important features of the network are (1) a semi-open structure to model limited bed capacity in addition to a limited physician capacity, (2) inpatient boarding, and (3) discontinuous treatment where patients may visit the physician more than once. Our analysis is numerical and exact: moreover, it is faster than the standard Quasi-birth-death method and simplifies the calculation of service levels in the external queue. We observe that boarding-reducing policies that focus on decreasing the boarding time perform better than policies that focus on decreasing the probability of boarding.

Key words: Markov-modulated fluid queue; emergency department; boarding; bed block

1. Introduction

Patients often need to wait in the emergency department (ED) to be admitted to the inpatient ward. This has been referred to in the medical literature as *inpatient boarding* (Chalfin et al., 2007; Moskop et al., 2009; Pines et al., 2011), *access block* (Fatovich et al., 2005; Gilligan et al., 2008), or *bed block* (Bair et al., 2010; El-Darzi et al., 1998; Helm et al., 2011), and has been identified as an important cause of ED crowding (Fatovich et al., 2005; Pines et al., 2011; Rabin et al., 2012; Trzeciak and Rivers, 2003). Moreover, it has been associated with increased ‘leaving without being seen’ (LWBS), worse patient outcomes and higher mortality rates (Bernstein et al., 2009; Trzeciak and Rivers, 2003). Boarding may occur because of bad synchronization between the ED and inpatient ward or a lack of staff, equipment, and beds in the inpatient ward (Armony et al., 2015; Shi et al., 2015). In spite of the severity and practical relevance of the problem, research on this topic has so far been limited in the OR/OM literature (Saghafian et al., 2015).

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