Economic value of norovirus outbreak control measures in healthcare settings

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Abstract

Although norovirus is a significant cause of nosocomial viral gastroenteritis, the economic value of hospital outbreak containment measures following identification of a norovirus case is currently unknown. We developed computer simulation models to determine the potential cost-savings from the hospital perspective of implementing the following norovirus outbreak control interventions: (i) increased hand hygiene measures, (ii) enhanced disinfection practices, (iii) patient isolation, (iv) use of protective apparel, (v) staff exclusion policies, and (vi) ward closure. Sensitivity analyses explored the impact of varying intervention efficacy, number of initial norovirus cases, the norovirus reproductive rate (R_0), and room, ward size, and occupancy. Implementing increased hand hygiene, using protective apparel, staff exclusion policies or increased disinfection separately or in bundles provided net cost-savings, even when the intervention was only 10% effective in preventing further norovirus transmission. Patient isolation or ward closure was cost-saving only when transmission prevention efficacy was very high (≥90%), and their economic value decreased as the number of beds per room and the number of empty beds per ward increased. Increased hand hygiene, using protective apparel or increased disinfection practices separately or in bundles are the most cost-saving interventions for the control and containment of a norovirus outbreak.

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Introduction

Norovirus has continued to be a threat in the community and in health care settings [1–4]. Norovirus is highly infectious and can spread rapidly in health care settings, consuming resources and resulting in longer hospital stays [5–8]. The average cost of a microbiologically confirmed nosocomial infection in the United States is estimated to be over $15 000 [9]. A 2007 norovirus outbreak at Johns Hopkins Hospital, a 946-bed hospital, cost an estimated $650 000 [2]. A 2003 outbreak cost a Swiss hospital $40 675 [10]. Outbreaks in the United Kingdom have been estimated to cost $1 million per 1000 hospital beds in 2002–2003 and cost the National Health Service (NHS) an estimated £1 billion annually [3].

Promptly identifying and preventing the spread of a norovirus outbreak may be keys to minimizing its impact. Health care facility administrators and infection control specialists have several containment interventions at their disposal including: (i) enhanced hand hygiene measures, (ii) contact isolation with protective apparel, (iii) isolation or cohorting of infected patients and staff, (iv) modified staff policies to exclude staff from work and prohibit exposed staff from working in unexposed areas, (v) modified visitor policies, (vi) enhanced disinfection practices through increased cleaning of wards and bathrooms, (vii) education of health care workers regarding identification of norovirus enhanced outbreak control measures, and (viii) active surveillance of the outbreak. Each of these interventions have associated costs, such as an increase in hygiene, protective and disinfection materials, reduction in number of available beds, and loss of staff time and productivity.

Deciding whether to implement various norovirus detection and control measures depends on the balance

between the costs of implementation and the potential cost-savings from each measure. To better understand this balance, we developed a computer simulation model that simulated the decision regarding whether to perform such strategies. Sensitivity analyses varied model parameters and allowed us to delineate how the cost-benefit of each strategy may vary by initial norovirus outbreak size, prevention strategy efficacy, and strategy cost. The results of our model may help guide policy making and the design of future clinical studies.

Methods

General model structure

Using TreeAge Pro Suite 2009 (TreeAge Software, Williamstown, MA, USA), which included Microsoft Excel (Microsoft Corporation, Redmond, WA, USA), we developed a stochastic, Monte Carlo decision analytical computer simulation model with dynamic transmission elements that simulated the decision regarding whether to implement a norovirus containment intervention. Fig. 1 outlines the model and the steps that follow the appearance of *n* primary norovirus cases (base case, 1) in a hospital ward. When no intervention was implemented, each infected primary case generated R_0 additional secondary cases, with R_0 being the reproductive rate (i.e. the expected number of new cases generated by a single infectious individual upon entering a fully susceptible population) [11]. Alternatively, implementing containment interventions reduced transmission (i.e. decreased R_0) proportional to the intervention's efficacy [effective reproductive rate $R_e = R_0*(1 - \text{intervention efficacy})$], which reflected the combination of the inherent efficacy of the intervention and compliance with the intervention. For example, if R_0 had a mean of 3.74 (range, 3.179–4.301), an intervention with an efficacy of 50% reduced R_0 by 50% to 1.87 (range, 1.59–2.15).

Each primary and secondary patient had a probability of being symptomatic or asymptomatic. Symptomatic patients experienced an increased length-of-stay (LOS), based on published studies (Table 1). This increased LOS resulted in occupied bed days that could have been used for other patients. A method described by Graves [12] translated these lost bed-days to opportunity costs. Asymptomatic patients did not experience increases in LOS but could transmit the virus. Each additional secondary case added cost based on their increased LOS. The model considered costs of only primary and secondary cases.

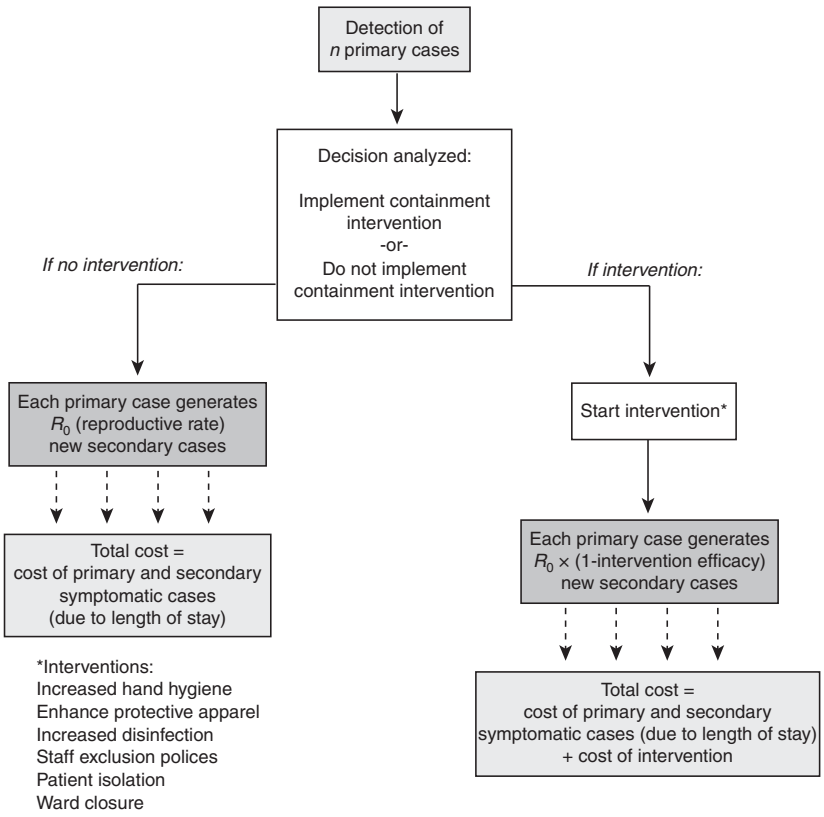

FIG. 1. Containment intervention strategy diagram.