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The inpatient costs and hospital service use associated with invasive meningococcal disease in South Australian children

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ABSTRACT

Background: Invasive meningococcal disease (IMD) remains a serious public health concern due to a sustained high case fatality rate and morbidity in survivors. This study aimed to estimate the hospital service costs associated with IMD and variables associated with the highest costs in Australian children admitted to a tertiary paediatric hospital.
Methods: Clinical details were obtained from medical records and associated inpatient costs were collected and inflated to 2011 Australian dollars using the medical and hospital services component of the Australian Consumer Price Index. Both unadjusted and adjusted analyses were undertaken. Multivariate regression models were used to adjust for potential covariates and determine independent predictors of high costs and increased length of hospital stay.
Results: Of 109 children hospitalised with IMD between May 2000 and April 2011, the majority were caused by serogroup B (70.6%). Presence of sequelae, serogroup B infection, male gender, infants less than one year of age, and previous medical diagnosis were associated with higher inpatient costs and length of stay (LOS) in hospital ($p < 0.001$) during the acute admissions. Children diagnosed with septicaemia had a longer predicted LOS ($p = 0.033$) during the acute admissions compared to those diagnosed with meningitis alone or meningitis with septicaemia. Serogroup B cases incurred a significantly higher risk of IMD related readmissions (IRR: 21.1, $p = 0.008$) for patients with sequelae. Serogroup B infection, male gender, diagnosis of septicaemia, infants less than one year of age, and no previous medical diagnosis were more likely to have higher inpatient costs and LOS during the IMD related readmissions for patients with sequelae ($p < 0.05$).
Conclusion: Although IMD is uncommon, the disease severity and associated long-term sequelae result in high health care costs, which should be considered in meningococcal B vaccine funding considerations.

1. Introduction

Neisseria meningitidis, is responsible for causing invasive meningococcal disease (IMD), a serious bacterial infection worldwide [1–4]. Six of thirteen *N. meningitidis* subgroups (A, B, C, W_{135}, X and Y) cause clinical disease [5–7]. Despite advanced antibiotic therapy, meningococcal disease remains a serious public health concern due to a sustained high case fatality rate of 5–15% with up to 57% of survivors developing sequelae [8–12,6]. Whilst meningococcal disease affects all age groups, surveillance data in developed countries such as the United States, European Union and Australia, show a bimodal age distribution with the highest rates in the 0–4 year age group and a second peak in the 15–24 year age group [6,13]. Children aged less than five years have the highest incidence

Abbreviations: CI, confidence interval; GLM, generalised linear model; HDU, high dependence unit; ICU, intensive care unit; IMD, invasive meningococcal disease; IRR, incidence rate ratio; JCVI, Joint Committee on Vaccination and Immunisation; LOS, length of stay; MenB, meningococcal B; MenC, meningococcal C.

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rate in Australia (average annual age-specific rate: 4.8 per 100,000 population) [14]. IMD is more commonly reported in infants less than one year of age worldwide [5,6,15,16].

Since the implementation of the national meningococcal C (MenC) vaccination programme in 2003 in Australia, the number of notifications of IMD has declined from 687 in 2002 to 241 in 2011 [13]. Serogroup B now predominates in Australia, with the proportion of laboratory-confirmed cases increasing 21%, from 63% in 2002 to 84% in 2011 [17,18]. A meningococcal B (MenB) vaccine (4CMenB vaccine, Bexsero®) has recently been licensed in Australia. Until recently, the Joint Committee on Vaccination and Immunisation (JCVI) in the UK did not recommend introduction of Bexsero® vaccine into the routine immunisation schedule based on results of cost-effectiveness analyses [19]. However, the JCVI has now determined Bexsero® to be included in the infant immunisation programme if a cost-effective price can be negotiated with the manufacture, Novartis Vaccines.

A number of studies estimating the costs of meningococcal disease were previously conducted in the US and Australia [9,11,20–23]. The US studies used ICD diagnosis codes which were not verified against laboratory results or hospital records [9,11,20–22]. This may lead to underestimation or overestimation of costs due to coding errors as acknowledged by the authors. In Australia, the only published study on the costs of IMD is Robinson's thesis in which only unadjusted total costs with a short follow-up period (one year) were reported [23]. The lifelong costs of treatment of acute meningococcal infection and management of long-term sequelae were estimated in a UK study by developing two severe scenarios of meningitis and septicaemia based on systematic reviews of the literature, interviews with IMD survivors and their families, and discussion with clinicians [24]. However, these were estimated costs rather than actual costs which relied on assumptions of resources used by survivors. As previous research data were not stratified by serogroup due to lack of serotype data, the economic impact of meningococcal B disease has not adequately been assessed.

Costing studies are required to estimate the cost saving and the medical benefits to inform public funding decisions such as immunisation programmes [25]. A number of previous cost-effectiveness studies of meningococcal vaccination programmes paid little attention to key drivers of economic evaluations including length of stay in hospital, proportion and length of stay in high dependence units (HDU) or intensive care units (ICU), proportion of survivors with long-term sequelae, and long-term costs associated with sequelae following IMD [26–31]. A recent economic evaluation study assessing MenB vaccination, has acknowledged the paucity of such data [32]. It has been recognised that the potential benefits of the meningococcal vaccination programme could be underestimated if the additional costs of managing long-term sequelae were overlooked [33].

Costs associated with inpatient services are a major component of health care utilisation in the management of IMD [9,11,21] and are important in estimating the overall direct cost burden of IMD. Our study aimed to estimate costs associated with IMD hospitalisation and sequelae in children and determine factors (e.g. serogroup, age and gender) significantly associated with high costs for future economic evaluation of new meningococcal vaccination programmes.

2. Methods

2.1. Study design and population

This study was conducted at a tertiary paediatric hospital in Adelaide, South Australia. The IMD cases were identified as per definitions previously reported [34]. Patients who developed sequelae, were followed from a range of 5–3659 days (mean [95% CI]: 645.8 [403.3–939.3]). For patients who had sequelae and were followed up at the tertiary paediatric hospital, the observation period was from the start of their acute admission stay to their last IMD related outpatient visit. For patients who had sequelae but were not followed up at this tertiary paediatric hospital, only the inpatient stay during the acute admission was included in the analyses. For those without sequelae, the observation period was the length of hospital stay during the acute admission, which varied from 1 to 19 days (mean [95% CI]: 5.3 [4.7–6.0]).

Clinical data on IMD hospitalisation in children aged <18 years between May 2000 and April 2011 were collected. Both laboratory-confirmed and probable (clinician diagnosis, unconfirmed laboratory diagnosis) cases were included in the study. Probable cases and laboratory-confirmed cases with serotypes C, W_{135}, Y and unknown were categorised as serogroup non-B disease. Clinical data such as patient characteristics and clinical outcomes were extracted from hospital and outpatient records. Direct medical costs were extracted from the hospital Health Informatics, Performance, Planning and Outcomes Unit, and included costs of medical ward, pathology, imaging, allied health (e.g. physiotherapy and speech pathology), pharmacy, use of theatre suite, the paediatric intensive care unit, prosthesis, medical and surgical supplies, hotel services, direct goods and services and overheads (those that do not provide services/care directly to patients, are allocated to direct patient areas as overhead costs i.e. finance, human resource, cleaning, etc.). In addition to acute admission costs, inpatient costs during the IMD related readmissions at this tertiary paediatric hospital were obtained for patients who developed sequelae. Older values were inflated to 2011 Australian dollars using the medical and hospital services component of the Australian Consumer Price Index [35].

2.2. Outcome measures

Outcome measures were the length of stay (LOS) in hospital during the acute admissions for all patients and during IMD related readmissions for patients with sequelae. Outcome measures were estimated by serogroup, age, gender, diagnosis type, absence or presence of a previous medical diagnosis and/or absence or presence of sequelae. The number of IMD related outpatient visits and frequency of IMD related readmissions in patients with sequelae following the primary admission were also outcome measures, reported as incidence rate ratios (IRR). The IRR is defined as a count of readmissions or outpatient visits among the exposed proportion of the study population such as patients infected with serogroup B disease, divided by the relevant count in the unexposed portion of the study population, which provides a relative measure of the effect of a given exposure.

2.3. Cost measures

Cost measures included inpatient costs during the acute admissions for all patients and during readmissions associated with IMD for patients with sequelae. Inpatient costs during the acute admissions were assessed in relation to serogroup, age, gender, diagnosis type, absence or presence of a previous medical diagnosis and absence or presence of sequelae. Inpatient costs during the readmissions for patients with sequelae, were estimated and compared by serogroup, age, gender, diagnosis type and absence or presence of a previous medical diagnosis.