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Impact of the national rotavirus vaccination programme on acute gastroenteritis in England and associated costs averted

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ABSTRACT

Background: Introduction of infant oral rotavirus vaccination in the UK in July 2013 has resulted in decreased hospitalisations and Emergency Department (ED) visits for acute gastroenteritis (AGE), for both adults and children. We investigated reductions in AGE incidence seen in primary care in the two years after vaccine introduction, and estimated the healthcare costs averted across healthcare settings in the first year of the vaccination programme.

Methods: We used primary care data from the Clinical Practice Research Datalink and age-stratified time-series analyses to derive adjusted incidence rate ratios (IRR_a) for AGE in the first two years of the post-vaccination era (July 2013-April 2015) compared to the pre-vaccination era (July 2008-June 2013). We estimated cases averted among children aged <5 years in the first year of the vaccination programme by comparing observed numbers of AGE cases in 2013–2014 to numbers predicted from the time-series models. We then estimated the healthcare costs averted for general practice consultations, ED visits and hospitalisations.

Results: In general practice, AGE rates in infants (the target group for vaccination) decreased by 15% overall after vaccine introduction (IRR_a = 0.85; 95%CI = 0.76–0.95), and by 41% in the months of historically high rotavirus circulation (IRR_a = 0.59; 95%CI = 0.53–0.66). Rates also decreased in other young children and to a lesser degree in older individuals, indicating herd immunity. Across all three settings (general practice, EDs, and hospitalisations) an estimated 87,376 (95% prediction interval: 62,588–113,561) AGE visits by children aged <5 years were averted in 2013–14, associated with an estimated £12.5 million (9,209–16,198) reduction in healthcare costs.

Conclusions: The marked decreases in the general practice AGE burden after rotavirus vaccine introduction mirror decreases seen in other UK healthcare settings. Overall, these decreases are associated with substantial averted healthcare costs.

1. Introduction

Rotavirus is the commonest cause of diarrhoea in young children, and results in considerable morbidity and healthcare utilisation [1–3]. Introduction of the monovalent live-attenuated oral vaccine Rotarix (GlaxoSmithKline Biologicals, Rixensart, Belgium) into national infant immunisation programmes has led to large decreases in both rotavirus-associated and all-cause acute gastroenteritis (AGE) hospital admissions [4–8]. In the UK, Rotarix was introduced in July 2013 as a 2-dose schedule given at 2 and 3 months of age. By the end of the first year, vaccine coverage reached 93% for one dose and 88% for two doses [9]. We have shown that vaccine introduction was followed by marked reductions in laboratory-confirmed rotavirus infections and AGE hospitalisations in England in the subsequent year [10]. Initial analyses using syndromic surveillance data also showed reductions in general practice consultations for gastroenteritis, diarrhoea and vomiting, and in emergency department (ED) visits for AGE [11].

Here we report in-depth analyses of the trends in incident AGE episodes presenting to general practice in England in the first two years after vaccine introduction (July 2013-April 2015). We also

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present estimates of the health care costs averted across NHS settings (general practice, EDs and hospital) in the first year of the vaccination programme because of reductions in AGE cases in young children.

2. Methods

2.1. Data sources

For the general practice analyses, we used data from the Clinical Practice Research Datalink (CPRD). This database contains anonymised primary care medical records from a representative 7% sample of the UK population [12]. Data available include all diagnoses and symptoms (coded using Read codes), referrals, prescriptions, and feedback from secondary care.

For healthcare cost estimates, we also used data on hospitalisations and ED visits. Hospitalisation data comprised Hospital Episode Statistics (HES), which contain information on all hospital admissions in England. ED attendance data were accessed from the Emergency Department Syndromic Surveillance System (EDSSS), a near real-time sentinel system that provides daily automated data extracts for ED visits [13]. We used EDSSS data from the eighteen participating EDs in England that used International Classification of Diseases version 10 or Snomed-CT diagnosis coding systems, to enable identification of AGE attendances.

Meteorological data, used to adjust for potential confounding by temperature and humidity in the general practice analyses, were downloaded from the UK Meteorological Office website and the MIDAS Land Surface Observation database [14–16].

2.2. AGE incidence in general practice

The study period comprised July 2008-June 2013 (the pre-vaccination period) and July 2013-April 2015 (the post-vaccination period). Individuals' start of follow up was the latest of their registration date with the practice (if ⩽3 months old at registration), six months after their registration date (if >3 months old, to avoid including historical AGE episodes recorded retrospectively after registration), the date the practice reached established quality standards and 1st July 2008 [17]. Follow up ended when the patient died or left the practice, when the practice stopped providing data or 30th April 2015.

Most infectious gastroenteritis presentations to general practice are diagnosed clinically without laboratory confirmation of the causative pathogen. Furthermore, general practitioners (GPs) often record gastroenteritis diagnoses using symptom codes such as "diarrhoea and vomiting". We therefore used a comprehensive list of Read codes to define AGE, categorising each code into one of four AGE subgroups: (AGE1) infectious gastroenteritis; (AGE2) non-infectious gastroenteritis of specified cause (e.g. "allergic gastroenteritis"); (AGE3) non-infectious gastroenteritis of unspecified cause; and (AGE4) gastroenteritis of unspecified type (e.g. "Diarrhoea and vomiting"; codelists available on request).

To accommodate multiple consultations for an ongoing illness, AGE diagnostic codes recorded ⩽28 days after a previous consultation were considered part of the same AGE episode. The first consultation within the episode was the incident date of that episode. Episodes of AGE first seen and diagnosed in hospital or in EDs (identified from the consultation type in the CPRD data) were excluded, to restrict analyses to AGE diagnosed in primary care. We then excluded episodes unlikely to be rotavirus AGE, namely episodes of non-infectious AGE of specified type (AGE2), and episodes of possible chronic diarrhoea, identified as AGE of unspecified type (AGE4) in individuals with pre-existing conditions that cause chronic diarrhoea (large bowel cancer, inflammatory bowel disease, irritable bowel syndrome, coeliac disease, cystic fibrosis, chronic pancreatitis, post-gastrectomy syndromes, post-bariatric surgery conditions or radiation colitis). In line with previous studies, non-infectious AGE of unspecified cause (AGE3) was retained in the primary analysis because previous investigations indicate that this is often a miscoding for infectious AGE [3,10].

Covariates of interest included age, subdivided into year of age for the first 5 years, then 5–14, 15–44, 45–64 and 65+ years; rotavirus epidemiological year (July-June); rotavirus season, classified based on historical rotavirus laboratory reports into high (February-April), medium (October-January, May) and low season (July-September, June). In each rotavirus year, temperature and rainfall were based on the median values of the daily mean central England temperature and rainfall for the two winter months (January, February) that captured the weather in the period spanning the start of rotavirus high season each year.

We performed age-stratified time series analyses of monthly counts of incident AGE cases, using negative binomial regression with an offset for the denominator (age-specific person-time). We included a variable in the model for the post-vaccination period to obtain adjusted incidence rate ratios (IRR_a) compared with the pre-vaccination period. Year was added to the model as a linear term to account for underlying secular trends. We initially considered using a longer pre-vaccination period (starting July 2003), but AGE counts in the earliest years were unusually low, which resulted in

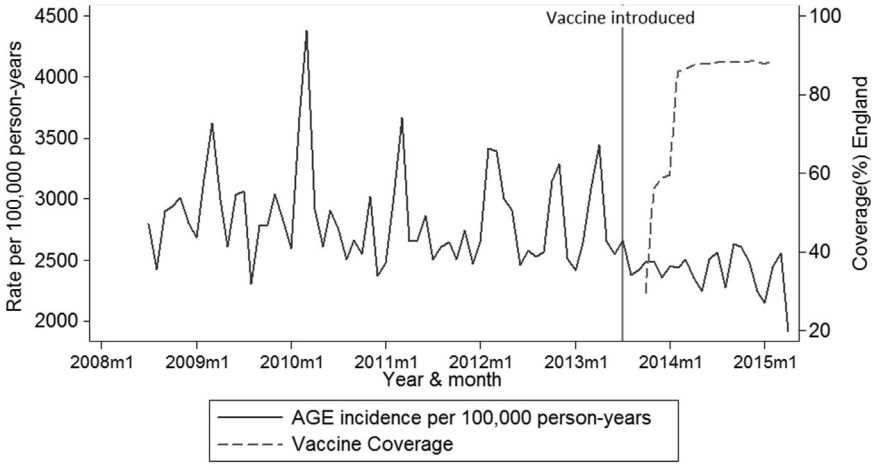

Fig. 1. Rates of new episodes of acute gastroenteritis (AGE) seen in UK primary care (per 100,000 person years), July 2008-April 2015.

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