Epidemiol. Infect. (2004), **132**, 619–626. © 2004 Cambridge University Press
DOI: 10.1017/S0950268804002250 Printed in the United Kingdom

Surveillance of childhood diarrhoeal disease in Hong Kong, using standardized hospital discharge data

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(*Accepted 12 February 2004*)

SUMMARY

Discharge information for all Hong Kong government hospitals, which is routinely collected through the Clinical Management System (CMS), was used to assess the relative importance of all causes of diarrhoeal illness and to address the issue of under-diagnosis of rotavirus by linking discharge diagnostic codes with actual laboratory results for one hospital. Of all children less than 5 years of age hospitalized in Hong Kong in the 2-year period July 1997 to June 1999, 12257 (11%) were discharged with a primary diarrhoea diagnosis (74% coded as non-specified, 10·4% as rotavirus, 11% as *Salmonella* and 5% as other viral or bacterial). Linked laboratory and discharge data for one hospital demonstrated that 15% ($n=1522$) of all admissions had a primary diarrhoea diagnosis and that 40% of these had a specimen sent for rotavirus testing, of which 37% were positive. However, 46% (67/145) of children with a diagnosis of rotavirus infection had no virology result, and 69% (172/248) of positive rotavirus results were in children with no diagnosis indicating rotavirus infection. Modification of the CMS to routinely combine existing computerized laboratory data with the CMS discharge diagnoses and to develop mechanisms to enhance reliability of discharge diagnosis coding could produce a powerful resource for disease surveillance, auditing and for monitoring the impact of future vaccination and other prevention programmes.

INTRODUCTION

Diarrhoeal diseases account for very significant mortality and morbidity in developing and developed countries. Prevention of diarrhoeal disease, particularly rotavirus, is an important public-health goal. Oral tetravalent rotavirus vaccine was expected to play a key role towards achieving this aim [1], but, unfortunately, the vaccine was withdrawn as a result of an association with intussusception [2–5]. Despite this setback, a number of other rotavirus vaccine candidates are in the pipeline, and their introduction is anticipated within the next few years.

Since the 1980s, a number of studies in Hong Kong have assessed the epidemiology of rotavirus and other diarrhoeal diseases [6–16]. In these studies, rotavirus accounted for approximately 30% of diarrhoea cases among hospitalized children [6, 7, 12, 15, 16] and

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Table 1. *Review of previous studies assessing rotavirus disease burden in Hong Kong*

Type and location of study [reference]	Years	Duration (months)	No. of diarrhoea admissions	Percent of admissions positive for rotavirus
Active surveillance studies				
Prince of Wales Hospital [7]	1994–1995	12	388	35
Queen Mary Hospital [12]	1982–1985	30	2228	30
Queen Mary Hospital [15]	1983–1985	30	2246	24
Queen Mary Hospital [16]	1983–1984	12	899	28·5
Passive surveillance and laboratory data				
Prince of Wales Hospital* [6]	1987–1996	120	7945	28
Community and laboratory studies				
Kwun Tong community [11]	1984–1986	36	637	11
Prince of Wales Hospital laboratory† [9]	1984–1990	80	3267	34
Government Virus Laboratory‡ [8]	1987–1992	72	27 618	14

* 2213 laboratory reports were positive for rotavirus in children <5 years of age during a period when 7945 children in this age group were admitted with a diagnosis of diarrhoea. However, only 14% of these diarrhoea admissions were for an illness classified as viral diarrhoea, indicating under-reporting in the patient discharge diagnosis.
† Study of positive isolates.
‡ 16·7% of stool specimens were positive for viruses, and 84·4% of virus isolates were rotavirus (all ages).

approximately 10% of those seen in the community (Table 1) [11]. However, data from one Hong Kong study suggests that bacterial diarrhoea rivals rotavirus, with approximately one-third of paediatric diarrhoeal admissions being due to rotavirus, one-third to bacterial causes, and one-third to no specific organism [7]. In previous studies, non-typhoidal salmonella were the most common bacterial pathogens isolated, and in contrast with other bacterial pathogens, such as *Shigella* and *Campylobacter* spp., salmonellae predominately caused diarrhoea in infants under 2 years of age [7, 9]. Children with *Salmonella*-related diarrhoea were also more likely to be given antibiotics and to have a greater number of stools per day and a longer duration of stay in hospital than children with rotavirus/non-specified diarrhoea [17].

Between 1984 and 1996, uniform discharge information was collected on all general paediatric patients admitted to the Prince of Wales Hospital (PWH), the main teaching hospital of the Chinese University of Hong Kong [18]. The data were used in a previous study that assessed the disease burden and economic costs of rotavirus infection [6]. From 1996, this data collection system has been replaced with the Clinical Management System (CMS). The CMS was introduced to collect uniform discharge and other information on all patients admitted to all publicly funded government (Hospital Authority, HA) hospitals. Hong Kong's 7 million people have access to HA hospitals at a nominal cost. We previously used this data source to estimate the incidence of rotavirus and intussusception among children under the age of 5 years hospitalized in Hong Kong [19]. We noted that 11% of all admissions had a primary diagnosis of diarrhoea, 14% had any diagnosis of diarrhoea, and 98% of admissions for rotavirus diarrhoea were under 5 years of age. Within the 12 different HA hospitals, the percentage of admissions with a diarrhoea-associated discharge code ranged from 10 to 19%, and the percentage of all diarrhoea-associated discharges coded as rotavirus diarrhoea ranged from 0 to 28%. It was estimated that active surveillance could identify rotavirus in approximately 4% of all paediatric medical admissions.

The present study uses the same data to assess disease burden and epidemiology of all diarrhoeal diseases among children hospitalized in Hong Kong over the 2-year period from 1 July 1997 to 30 June 1999. In addition, we have linked the CMS data from one of the HA hospitals with laboratory data to correlate discharge diagnosis codes with laboratory identification of rotavirus.

METHODS

Analysis of CMS data source

Information collected by using the CMS includes patient identifiers, date of birth, sex, a maximum of

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15 diagnoses and 15 procedures (classified by International Classification of Diseases, ICD9-CM, codes), and admission and discharge dates. Paediatric patients with medical and surgical conditions are admitted to separate wards of government hospitals in Hong Kong. A database of paediatric patients hospitalized in medical wards at the 12 government hospitals admitting such patients from 1 July 1997 to 30 June 1999 was provided by the HA data centre. Details of infants admitted to neonatal units were excluded. The following ICD9-CM codes were used to define diarrhoea hospitalizations: 001–005, excluding 003·2, and 008·0–008·5 (bacterial diarrhoeas); 006–007, excluding 006·2–006·6 (parasitic diarrhoeas); 008·61 (rotavirus diarrhoea); 008·6–008·8 (other viral diarrhoeas); 009·0–009·3 (diarrhoea of undetermined aetiology, including that presumed to be infectious); and 558·9 and 787·91 (other non-infectious diarrhoeas). Although children with gastroenteritis who have no pathogen isolated should be correctly coded as ICD 009·0–009·3, it is apparent that ICD codes 559·9 and 787·91 are often being used instead. Thus for the presentation of data, diarrhoeas of undetermined and non-infectious aetiology were grouped together as 'non-specified diarrhoea'. Classification into one of these groups was made if any of these codes were listed as the primary diagnosis. A second classification of 'diarrhoea-associated admissions' was made if any of these codes were listed as any of the 15 possible diagnostic codes.

Linking of CMS with laboratory data for PWH

All admissions from one of the HA hospitals (PWH) were matched using the unique hospital number, with identifier information available within the Paediatric Department's audit system (PWH database). A total of 10 231 general paediatric patients under the age of 5 years (16 844 under 15 years) admitted to PWH during this period could be matched to the PWH database. Although the PWH database during this period was derived from the CMS, some discrepancies were identified in the discharge diagnoses between the two data sources, i.e. 10 298 admissions in the CMS database. One hundred and eleven patients (1·1%) in the CMS database could not be matched with the PWH database, and 96 non-neonatal admissions (0·9%) in the PWH database could not be matched with the CMS database. Of those patients who could be matched, a few had discharge diagnoses that differed between the two databases, presumably as a result of changes made after the data had been downloaded. These combined PWH and CMS data were then linked with the PWH laboratory data. Of the 57 351 laboratory tests from 7310 subjects who had a valid and unique hospital number, 29 349 tests had a hospital number that could be matched with those of children in the PWH/CMS database containing the discharge diagnoses. Those tests with no hospital number were matched with the subject's unique Hong Kong identity number, which gave an additional 54 tests. A proportion of tests had no admission date ($n=205$), a collection date before the date of hospital admission ($n=6859$), or a collection date after the date of hospital discharge ($n=790$). Tests with a collection date beyond hospital stay were further examined, and 3509 were found to have mismatched hospital numbers, which were corrected. The final number of tests available for matching was 25 058 from a total of 4160 subjects, i.e. 41% of general paediatric admissions.

RESULTS

During the 2-year study period, 169 082 children were admitted to HA medical paediatric wards; 94% (159 677) were under the age of 15 years and 63% (106 919) were under the age of 5 years. A total of 2720 different ICD codes were used. Causes of diarrhoea morbidity were assessed for admissions of children less than 5 years of age.

No aetiological agent was identified for most cases: 47% of diagnoses were coded as 'diarrhoea of presumed infectious origin', and 27% were coded as 'diarrhoea of presumed non-infectious origin'. Rotavirus diarrhoea (10%) and *Salmonella* sp. (11%) were the most common specific diagnoses, followed by other bacteria and food poisoning (2·8%), and other virus (1·5%) (Table 2). Within the 12 different HA hospitals, there was considerable variation in the proportion of admissions for all diarrhoea, rotavirus, and *Salmonella* (Table 3). For all admissions and for most diarrhoea subcategories, males outnumbered females (58% *vs.* 42%). Children with bacterial diarrhoeas had a median hospital stay of 4 days [interquartile range (IQR), 2–7], a period similar to that for rotavirus hospitalizations but longer than that for children with viral diarrhoeas or other non-specified diarrhoeas (3 days; IQR, 2–4).

We examined the age distribution of children with a discharge diagnosis of rotavirus, bacterial diarrhoea

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Table 2. *Diarrhoea hospitalizations by reported diagnosis among 106 919 children aged 1–59 months* (*Hong Kong government hospitals from 1 July 1997 to 30 June 1999*)

Aetiology of diarrhoea hospitalization	ICD codes	Primary diagnosis no. (%)	Ratio M/F (%)
Non-specified diarrhoeas			
Presumed infectious	009·0–009·3	5753 (46·9)	57:43
Presumed non-infectious	558·9, 789·91	3358 (27·4)	57:43
Viral*	008·6–008·8	183 (1·5)	48:52
Rotavirus	008·61	1270 (10·4)	58:42
Cholera	001–001·9	1 (0)	100:0
Salmonella sp.	002–003·9	1347 (11·0)	53:47
Shigella	004–004·9	66 (0·5)	59:41
Food poisoning	005–005·9	38 (0·3)	59:41
Escherichia coli and others	008–008·5	241 (2·0)	62:38
Total diarrhoea		12 257 (11·5%)	57:43
Total of all other diseases		94 662 (88·5%)	58:42

* Excludes rotavirus.

Table 3. *Number* (*%*) *of hospital admissions, by hospital, for rotavirus-associated* (*n* = *1607*) *and Salmonella-associated* (*n* = *1544*) *diarrhoeas among 14 747 children aged 1–59 months hospitalized for any diarrhoea* (*primary diagnosis or any one of 14 secondary diagnoses*) *in Hong Kong Hospital Authority hospitals, 1 July 1997 to 30 June 1999*

Hospital (total no. of admissions)	Total no. (%) diarrhoea-associated admissions*	No. (%) admitted for rotavirus-associated diarrhoea*	No. (%) admitted for *Salmonella*-associated diarrhoea*
A (113 10)	1745 (15·4)	486 (27·9)‡	199 (11·4)
B (8231)	1152 (14·0)	262 (22·7)‡	142 (12·3)
C (9153)	938 (10·2)	189 (20·1)‡	138 (14·7)
D (2181)	326 (14·9)	43 (13·2)‡	27 (8·3)
E (9473)	1293 (13·6)	166 (12·8)‡	184 (14·2)
F† (10 298)	1667 (16·2)	135 (8·1)‡	112 (6·7)
G (5276)	728 (13·8)	55 (7·6)§	50 (6·9)
H (8608)	1495 (17·4)	102 (6·8)§	136 (9·1)
I (6170)	1182 (19·2)	74 (6·3)§	127 (10·7)
J (16 032)	1876 (11·7)	88 (4·7)‡	202 (10·8)
K (12 875)	1475 (11·5)	7 (0·5)§	128 (8·7)
L (7312)	870 (11·9)	0 (0)§	99 (11·4)
Total (106 919)	14 747 (13·8)	1607 (10·9)	1544 (10·5)

* Any of 15 possible diagnosis codes.
† Prince of Wales Hospital data linked to laboratory data (Table 4).
‡ Policy for stool specimens to be sent for rotavirus testing for all or most diarrhoea admissions.
§ Policy for stool specimens sent for rotavirus testing for selected diarrhoea admissions only (e.g. complicated or chronic cases).

and non-specified diarrhoea (Fig. 1). Overall, the age distributions were similar, and children with bacterial diarrhoeas tended to be younger. The seasonality of diarrhoea demonstrated a distinct winter peak for rotavirus and non-specified diarrhoea but a summer peak for bacterial diarrhoeas (Fig. 2).

The PWH (Hospital F in Table 3) analysis linking discharge diagnostic data with laboratory data

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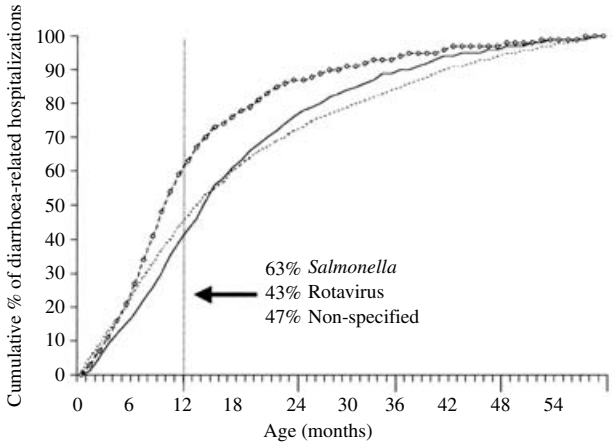

Fig. 1. Cumulative percentage of rotavirus, bacterial and total diarrhoea hospitalization (primary diagnosis only) among children aged 1–59 months, Hong Kong government hospitals, 1 July 1997 to 30 June 1999. By 12 months of age, 63% of *Salmonella*, 43% of rotavirus and 47% of non-specified diarrhoeas in this age group had occurred. Fifty per cent of infections had occurred by 10 months in the *Salmonella* group (- - ◇ - -), by 13 months in the non-specified group (·····) and 14 months in the rotavirus group (——).

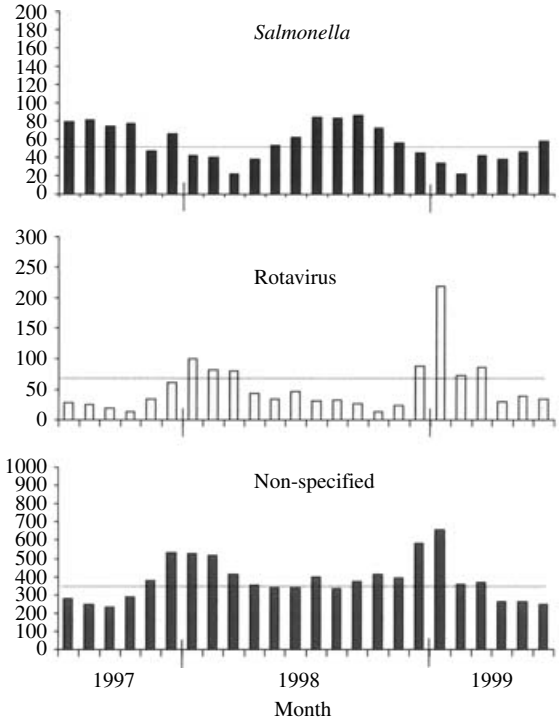

Fig. 2. Seasonality for different causes of diarrhoea hospitalizations (primary diagnosis only) among children aged 1–59 months, Hong Kong government hospitals, 1 July 1997 to 30 June 1999.

demonstrated that 1522 (15%) of the 10231 general paediatric admissions under the age of 5 years had a primary diagnosis of diarrhoea (Table 4). Of all children with a primary diagnosis of diarrhoea, 40% had a specimen sent for rotavirus testing, as did 3·1% of children with non-diarrhoea primary diagnoses. Of all specimens sent from patients with a primary diagnosis of diarrhoea, 37% were positive for rotavirus. A total of 76 children had a diagnosis of rotavirus diarrhoea and a positive laboratory identification of rotavirus. An additional 172 children had rotavirus identified on a stool specimen but did not have any discharge diagnosis code that indicated that rotavirus had been identified. In addition, 69 children had a diagnosis listed as rotavirus diarrhoea but did not have any laboratory diagnosis of rotavirus, and 67 of these children did not have any record that a specimen had been tested for rotavirus (2 were tested and reported as negative). A CMS rotavirus diagnosis would have a positive predictive value of 52% [76/(76 + 69)] that the laboratory result will be positive for rotavirus.

DISCUSSION

In our previous report analysing rotavirus and intussusception data derived from the CMS database, we concluded that rotavirus was an important cause of hospitalization of children under the age of 5 years in Hong Kong [19]. However, we considered it likely that this data source was underestimating the true disease burden of rotavirus, emphasizing the importance of active surveillance. We now have extended the analysis of the data to examine in detail all causes of diarrhoea and have further addressed the issue of under-diagnosis of rotavirus by comparing the discharge information from the CMS with virology results from one of the 12 hospitals in the database (Hospital F, Table 3).

Previous studies from individual hospitals performing rotavirus screening have indicated that approximately 30% of diarrhoea admission are due to rotavirus (Table 1) [6, 9, 12]. One of these studies was performed at PWH and compared clinical audit data and laboratory data to assess the epidemiology and disease burden of rotavirus infection [6]. During the 10-year study period (1987–1996), 71% of general paediatric admissions (excluding neonatal and oncology admissions) were aged less than 5 years and 17% had a primary discharge diagnosis of acute gastroenteritis (13% non-specified, 2·2% bacterial, 2·6% viral). The latter viral diarrhoeas accounted for 1120 cases, and even if all were due to rotavirus, this

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Table 4. *Diarrhoea hospitalizations* (*primary diagnosis only*) *reported from the Clinical Management System among 10 231 children aged 1–59 months admitted to the Prince of Wales Hospital, Hong Kong, from 1 July 1997 to 30 June 1999, compared with actual rotavirus results from virology laboratory*

Aetiology of diarrhoea admissions	ICD code(s)	No. (%) with clinical diagnosis*	No. (%) with specimen sent to virology laboratory	No. (%) diagnosed rotavirus positive
Presumed infectious	009·0–009·3	564 (37)	223 (39·5)	58 (26·0)
Presumed non-infectious	558·9, 787·91	578 (38)	201 (34·8)	63 (31·3)
Viral†	008·6–008·8	130 (8·5)	43 (33·1)	28 (65·1)
Rotavirus‡	008·61	120 (7·9)	71 (59·2)	69 (97·2)
Cholera	001–001·9	0	0	0
Salmonella sp.	002–003·9	109 (7·2)	60 (55·0)	8 (13·3)
Shigella	004–004·9	7 (0·5)	4 (57·1)	1 (25·0)
Food poisoning	005–005·9	3 (0·2)	1 (33·3)	0
Escherichia coli and others	008–008·5	11 (0·7)	6 (54·1)	1 (16·7)
Total diarrhoea		1522 (100)	609 (40·0)	228 (37·4)
All other diseases		8709	266 (3·1)	20 (7·5)

* Primary diagnosis code only.
† Excludes rotavirus.
‡ Policy to screen children with diarrhoea for rotavirus.

number was approximately half of the 2213 laboratory isolates of rotavirus in children aged under 5 years during the same period.

In the present study, we further examined this issue of under-reporting by passive surveillance by linking actual discharge diagnoses derived from the CMS data source with the laboratory rotavirus results for those children admitted to PWH. This analysis showed that 46% (67/145) of those children who had any diagnosis of rotavirus infection in the CMS database did not, in fact, have a record of a stool sample being sent to the virology laboratory. Conversely, 69% (172/248) of all positive rotavirus isolates were in children who did not have a CMS diagnosis indicating rotavirus infection. There were 7·5% of children without a diarrhoea diagnosis that were also rotavirus positive. It is possible that a proportion of the latter cases could represent nosocomial infection. Although it has long been routine practice at the PWH to send all diarrhoeal stools for rotavirus testing, only 40% of all children with a primary discharge diagnosis of diarrhoea had a stool specimen sent for rotavirus testing, with 37% being positive (Table 4). Although it might be argued that had stool specimens been sent for all patients with diarrhoea, a similar high proportion would have been positive for rotavirus, this may not in fact be the case. Reasons why stool specimens are not sent are likely to be varied, but severity of diarrhoea could be one factor that could favour specimens being sent for rotavirus diarrhoea but not for other causes of milder diarrhoea. If all diarrhoea-associated admissions have a rotavirus positivity rate of approximately 37%, then an estimated 5·5% of all general paediatric admissions under the age of 5 years would be due to rotavirus. However the positivity rate may be significantly less than 37% for those patients with milder cases of diarrhoea and who did not have a stool specimen sent.

This linked analysis gives greater insight into coding discrepancies of discharge diagnoses recorded in the CMS and highlights an important limitation of this data source, i.e. the unknown reliability of the ICD coding. ICD codes are entered by the responsible medical officer and are, therefore, dependent on the information available at the time of discharge and on the ability of the medical officer to locate the correct diagnosis through the CMS. The CMS allows for the ICD code to be entered directly if known. The ICD code will then appear with the linked diagnosis that can then be checked by the doctor. As an alternative, the desired diagnosis can be located by using a keyword search. This process implies that the coding varies between medical officers and between hospitals. Laboratory results confirming rotavirus or bacterial infection may be returned to the ward after the discharge diagnosis data have been completed. In some cases, the medical officer may update the discharge diagnosis, but in most cases, this is unlikely to occur. Discrepancies in discharge diagnoses may also reflect the fact that the discharging doctor may find it easier to remember certain ICD codes (e.g. 009·3 for non-specific diarrhoea may be easier to recall than 008·61

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for rotavirus). It is possible that some of the discrepancies between the CMS discharge diagnosis and the laboratory result could relate to the fact that not all laboratory results had a valid hospital number that could be matched to the patients in the CMS database.

Salmonella-related diarrhoea is a significant problem among children in Hong Kong [17], and the present analysis confirms its relative importance. *Salmonella* infection as a primary diagnosis was identified in 11% of all paediatric admissions under the age of 5 years with diarrhoea (Table 2). However as for rotavirus, this figure may be an underestimate, given that a previous prospective study indicated that approximately 25% of diarrhoea admissions were due to *Salmonella* sp. [7]. The inter-hospital variation in the proportion of children coded as *Salmonella* was less than that for rotavirus but still significant (6·7–15%) (Table 3). In the present subanalysis of data from the PWH, we did not link microbiological data with the CMS discharge diagnoses. Such an analysis would give additional insight into the extent to which diarrhoea due to *Salmonella* infection is under-reported.

Another limitation of using uniform discharge data from all HA hospitals in Hong Kong is that private hospital data are not included. Hong Kong has a dual public and private system for both primary and secondary health care. The CMS data provide no information on admissions to private hospitals or for visits to primary-care practitioners, either public or private. However, a household survey assessed the 6-month in-patient utilization rate and average length of stay by age (excluding free care) [20]. For children under the age of 4 years, the public hospital utilization rate was 10% and the private hospital utilization rate was 3·3%, indicating that young children are three times more likely to use the public hospital system. Due to the smaller proportion of children admitted to the private sector, we believe that the data presented in this study provide a reasonable overview of the hospitalization patterns for children with diarrhoeal illness in Hong Kong.

Routinely collected HA hospital discharge data collected through the CMS are likely to underestimate the true disease burden of conditions such as rotavirus- and *Salmonella*-related diarrhoeas. The CMS data suggested that 10% of diarrhoea admissions were due to rotavirus, whereas the laboratory data showed that 37% of all stools tested were positive for rotavirus. This suggests that rotavirus is under-reported by the CMS by a factor of 3–4. However, despite limitations, the CMS database of discharge information is an important resource that could be incorporated into diarrhoeal disease surveillance protocols to monitor diarrhoea admissions and identify possible under-reporting by specific hospitals. Enhancement of the CMS to routinely combine all existing computerized laboratory data with the computerized discharge diagnosis information would be of significant benefit and plans to do this are underway. It is also important to improve the reliability of discharge coding by medical staff and regular audits are now underway to address this problem. Other options to explore would be modifying the CMS to prompt medical staff with available laboratory results when discharge codes are entered. Ideally the CMS should have a mechanism that would routinely ensure that discharge diagnoses are updated, if necessary, when laboratory results become available. Once the CMS routinely links laboratory data with discharge data, health planners will be better able to audit discharge diagnostic coding practices within and between government hospitals and improve reliability. The CMS has the potential to be an extremely valuable tool for disease surveillance and monitoring the impact of future vaccination and other prevention programmes.

ACKNOWLEDGEMENTS

We thank the Hospital Authority Head Office for providing data from the Clinical Management System and Dr Fung Hong for helpful comments and advice.

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