Rotavirus vaccination coverage and adherence to recommended age among infants in Flanders (Belgium) in 2012

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In Belgium, rotavirus vaccination has been recommended and partially reimbursed since October 2006. Through a retrospective survey in 2012, we estimated the coverage rate of the rotavirus vaccination in Flanders among infants born in 2010. Using a standardised questionnaire, 874 families were interviewed at home, collecting information on demographic characteristics, socio-economic background and documented vaccination history (updated from medical files and vaccination database, if needed). Adherence to the recommended age for vaccination (8, 12 and 16 weeks) was also assessed. The coverage rate for two doses of rotavirus vaccination was 92.2% (95% confidence interval: 90.2–93.8). Respectively 31.7% and 10.1% of the children received their first and second dose at the recommended age. Incomplete vaccination was often a deliberate choice of the parents. Only eight children (1%) were vaccinated after the maximum age of 26 weeks. Factors identified by multiple logistic regression as related to incomplete vaccination were: living in the province of Antwerp, unemployed mother, and three or more older siblings in the household. Four years after introduction, the coverage rates were surprisingly high for a vaccine that is not fully reimbursed and not readily available in the vaccinator's fridge, which is the case for the other recommended infant vaccines.

Introduction

Rotavirus is the most common cause of fatal and severe childhood diarrhoea worldwide. The introduction of rotavirus vaccination into national immunisation programmes has contributed to a significant decrease in rotavirus gastroenteritis-related mortality and morbidity [1,2]. In Belgium, the national immunisation technical advisory group (NITAG) recommended rotavirus vaccination in October 2006. Unlike other infant vaccines in the national immunisation schedule, rotavirus vaccination is not offered fully free of charge by the government. If parents wish to have their child vaccinated against rotavirus, they need a prescription for the vaccine, via a well-baby clinic, general practitioner or paediatrician. Both vaccines, Rotarix (two-dose schedule) and RotaTeq (three-dose schedule), are only available in private pharmacies in Belgium. The partial reimbursement system entails that parents pay EUR 11.60 per prescribed vaccine dose, the National Health Insurance covers the remaining EUR 59.60 per Rotarix vaccine and EUR 40.10 per RotaTeq vaccine. Following the national recommendations issued by the NITAG, the first dose of rotavirus vaccine should be administered at eight weeks of age. A minimum interval of four weeks between doses should be respected and the upper age limit is set at six months (24 weeks for the monovalent Rotarix vaccine and 26 weeks for the pentavalent RotaTeq vaccine, according to the recommendations issued in 2009). Catch-up vaccination of missed doses above this age is not recommended. Concomitant administration of rotavirus vaccine with other infant immunisations is approved [3].

In 2008, vaccine coverage in children 18 to 24 months of age in Flanders was approximately 30% for two doses of the rotavirus vaccine, as measured by a survey using the World Health Organization's Expanded Programme on Immunization (EPI) methodology [4]. This low rate could be explained by the recent introduction of the vaccine in Belgium at that time. More recent coverage estimates for rotavirus vaccination were based solely on sales and reimbursement figures provided by the National Health Insurance [5].

With this study we aimed to investigate coverage rates for rotavirus vaccination among infants born in 2010 in

Flanders. We also looked at timeliness of vaccination with regard to recommended age and assessed the validity of the vaccine doses taking into account minimum and maximum age and interval parameters. Using survey-based multiple logistic regression we identified predictive factors for non-vaccination.

As Belgium was the first country in the European Union (EU) to introduce a universal rotavirus vaccine programme, these coverage estimates could contribute to the decision-making process for rotavirus vaccine introduction in other countries. Putting the results into perspective of our co-financing policy may provide insights into equitable distribution of rotavirus vaccines.

Methods

Survey Design

The methodology of the EPI-based two-stage cluster sampling design for vaccination coverage studies in Flanders has been extensively described elsewhere [6]. The sample size was calculated using the following assumptions: a minimal anticipated coverage of 90% and a design effect of 1.5. Taking into account a margin error of the confidence interval of 2.5% and a drop-out rate of 10%, this resulted in a sample size of 900 children.

A cluster random sample of toddlers (born between 1 July and 1 October 2010) was drawn from the Flemish register of natural persons. Firstly, 125 clusters proportionally distributed over the 14 districts (representing the third administrative level) of Flanders, were selected in a proportionate random way. In a second stage, seven children of eligible age were randomly selected per cluster. An overselection of 70 children in less densely populated districts was done to assure acceptably accurate estimates on coverage rates in those geographical regions. Selected families were informed by letter of a home visit by a trained interviewer. Children were replaced within the same cluster when (i) the interviewer was not able to contact the family after three home visits, of which one was after office hours, or (ii) the interviewee was not able to understand the questions because only a Dutch version of the questionnaire was available. If parents refused to participate, they were asked to state the reason for refusal, and the child was not replaced in order to reduce the risk of selection bias, as refusal could be linked with a negative attitude towards vaccination.

The visits were performed between 25 April and 7 July 2012, so all participating children should have completed their vaccination according to the schedule. Informed consent from a parent or caregiver had to be obtained for the full data collection procedure. The following information was collected through a standardised questionnaire: demographic characteristics, socio-economic background and documented vaccination history. The vaccination data available at home were checked against the Flemish immunisation registry, Vaccinnet, and completed if more information was available in that database. Thereafter, the collected data from children who were still not found to be vaccinated appropriately for their age were sent to the general physician or paediatrician (when contact information was available) with a request to verify, correct and/or complete these data.

This study was authorised by the National Privacy Commission and received approval on 16 April 2012 from the ethics committee of the Antwerp University Hospital, after consulting the ethics committee of the University of Leuven (KULeuven).

Definitions

To assess adherence to the recommended age of vaccination, we compared the vaccination history of the child with the recommended number of doses, the minimum and maximum allowed age for each dose and the minimum acceptable interval between doses. Following the national guidelines, the first rotavirus vaccine dose should be administered at the age of eight weeks, with an interval between consecutive doses of four weeks, and the last dose before the age of six months (i.e. 26 weeks). Doses that were not documented on the vaccination card, or could not be retrieved through consultation of medical files and Vaccinnet, were considered as not administered. Only the date of administration of the rotavirus vaccine was registered in the questionnaire, the brand name was not requested because this is usually not indicated in the vaccination card. Since we could not make a distinction between the two different rotavirus vaccine brands, we considered a schedule with at least two doses as complete. We defined a valid schedule as a complete schedule where all minimum and maximum age recommendations and interval parameters were strictly respected. We excluded doses that were administered more than five days before the minimum age or with an interval from the previous dose that was more than five days shorter than allowed, and doses that were administered after the age of 26 weeks. The ethnic background of parents was determined based on their country of birth as well as that of their parents (the child's grandparents): if one of them was born outside the EU (27 countries, as of 2012), the parent was categorised as non-European; if a parent or grandparent was born in the EU, but not in Belgium, the parent was categorised as European, otherwise as Belgian.

Statistical analysis

Oversampling was adjusted for by weighing if appropriate. Vaccine coverage analysis was performed using R 2.15.2 *(The R Foundation for Statistical Computing, 26-10-2012)* and presented with a 95% confidence interval (CI). We examined whether the following characteristics were related to the vaccination status at the age of 18 months: sex, main vaccinator, change of vaccinator, number of illnesses, family structure, hierarchy within the family, number of children in the family,

Table 1

Vaccination coverage at the age of 18 to 24 months per province in Flanders, 2012 (n=874)

	Antwerp[a] n=226	Limburg n=120	East Flanders n=200	Flemish Brabant n=146	West Flanders n=182
	Coverage rate (95% confidence interval)				
Rota 1*	89.8 (85.3–93.1)	98.3 (93.6–99.6)	97.0 (93.3–98.6)	94.5 (89.4–97.2)	92.9 (88.0–95.9)
Rota 2**	88.1 (83.3–91.6)	97.5 (92.3–99.2)	94.0 (89.7–96.6)	93.8 (88.5–96.8)	90.7 (85.3–94.2)

[a] For two children no documentation could be retrieved for any recommended vaccine; they were considered not vaccinated.

*p=0.013

**p=0.028

socio-economical characteristics of mother and/or father, family income, day care attendance, breastfeeding and duration of breastfeeding. Final models were selected using a backward selection, p values ‹0.05 were considered significant. Both survey-based univariate and multiple logistic regression were analysed using R 2.15.2 *(The R Foundation for Statistical Computing, 26-10-2012)*.

Results

Study population

In total, 1,064 families were contacted, including replacement contacts for 118 families (11.1%). Among the 946 families who were reached, 874 families (92.4%) participated in the study, while 72 families refused to participate (7.6%). The mean age of the children at the moment of interview was 20.9 months (age range: 18.5–23.9 months). The study population consisted of 49.9% males. All demographic characteristics, except employment status of the parents, were in line with national census estimates for these age groups. Among the participating families we found a higher proportion with both parents employed.

Coverage rate

In 92.1% of the families, a vaccination document was available at home. After additional consultation of medical files and vaccination database (Vaccinnet), 94.0% of the children between 18 and 24 months of age had proof of administration of at least one dose of rotavirus vaccine. A second dose had been administered to 92.2% of these children and 12.2% had received a third dose. A sensitivity analysis, considering as not vaccinated against rotavirus the children for whom the parents refused to participate in the coverage study (worst case scenario), resulted in a coverage decrease of 7% for each dose.

Table 1 shows a statistically significant difference in vaccination coverage between provinces, with the lowest coverage in the province of Antwerp (p=0.013 for the first and p=0.028 for the second rotavirus vaccine dose). There was also a statistically significant difference between the three districts within the Antwerp province, with the lowest coverage found in the most urbanised district, Antwerp city (Table 2).

Validity and timeliness

The so-called valid coverage rate for two doses was 90.5%. One child had received the first dose before the age of eight weeks, six children had received the second dose less than four weeks after the first, and eight other children were vaccinated after the age of 26 weeks; these doses were considered invalid.

Table 3 shows the compliance of rotavirus vaccination with the age recommendations. While 31.7% of the vaccinated children received their first dose at the recommended age, correct timing dropped to 10.1% for the second dose. In almost 30% of the children, the second dose was administered more than four weeks after the recommended age.

Assessment and parents' reasons for incomplete vaccination

At the beginning of the interview, the parents were asked to assess the vaccination status of their child (i.e. complete or not). Among the 68 children with an incomplete rotavirus vaccination schedule (excluding the 15 children who had received invalid doses outside the recommended time period), 57 parents (84%)

Table 2

Vaccination coverage at the age of 18 to 24 months per district in Antwerp, 2012 (n=226)

	Antwerp n=114	Mechelen n=53	Turnhout n=59
	Coverage rate (95% confidence interval)		
Rota 1*	83.3 (75.3–89.1)	96.2 (86.1–99.1)	96.6 (87.4–99.2)
Rota 2**	79.8 (71.5–86.2)	96.2 (86.1–99.1)	96.6 (87.4–99.2)

*p=0.003

**p=0.003

Table 3

Distribution of age at vaccination according to the guidelines of the Superior Health Council, Flanders, 2012 (n=874)

	Not	Too early	At recommended age[a]	1–3 weeks too late	4–7 weeks too late	≥ 8 weeks too late
	Number (%)					
Rota 1	52 (6.0%)	1 (0.1%)	277 (31.7%)	388 (44.4%)	119 (13.6%)	37 (4.2%)
Rota 2	68 (7.8%)	-	88 (10.1%)	457 (52.3%)	165 (18.8%)	96 (11.0%)

[a] At recommended age was defined as not before minimum age and not more than six days after the recommended age according to the guidelines (Rota 1 at eight weeks; Rota 2 at 12 weeks).

Table 4

Predictive factors for having received an incomplete schedule for rotavirus vaccination (logistic regression, univariate analysis), Flanders, 2012

		Odds ratio	95% CI
Province (n=874)	Limburg (n=120)	**0.20**	**0.06–0.67****
	East Flanders (n=200)	**0.44**	**0.21–0.91***
	Flemish Brabant (n=146)	0.50	0.23–1.10
	West Flanders (n=182)	0.79	0.41–1.52
	Baseline: Antwerp (n=226)	**1**	
Day care attendance during the first year of life (n=873)	Non-professional day care (n=75)	0.93	0.35–2.50
	Combination (professional and non-professional day care) (n=112)	0.26	0.06–1.08
	No attendance (n=165)	**2.17**	**1.23–3.85****
	Baseline: professional day care (n=521)	**1**	
Main vaccinator[a] (n=864)	Paediatrician (n=104)	1.43	0.65–3.13
	General practitioner (n=31)	**6.67**	**2.86–14.29****
	Baseline: well-baby clinic (n=729)	**1**	
Number of older siblings in the household (n=874)	None (n=76)	1.79	0.76–4.17
	One (n=304)	0.76	0.37–1.54
	Two (n=114)	1.56	0.70–3.45
	Three or more (n=49)	**5.26**	**2.38–11.11****
	Baseline: only child (n=331)	**1**	
Family income (n=755)	EUR 2,001–3,000 (n=227)	**0.38**	**0.18–0.78****
	EUR 3,001–4,000 (n=313)	**0.32**	**0.16–0.65****
	› EUR 4,000 (n=92)	**0.18**	**0.06–0.63****
	Baseline: ≤ EUR 2,000 (n=123)	**1**	
Mother's employment situation (n=869)	Part-time salary (n=213)	1.04	0.49–2.22
	Self-employed (n=27)	2.44	0.68–9.09
	Unemployed (n=211)	**3.33**	**1.89–6.25****
	Baseline: full-time salary (n=418)	**1**	
Origin of the mother (n=869)	Other EU country (n=60)	1.59	0.59–4.17
	Outside EU (n=159)	**2.94**	**1.69–5.00****
	Baseline: Belgium (n=650)	**1**	
Father's employment situation (n=819)	Part-time salary (n=16)	0.91	0.12–7.14
	Self-employed (n=92)	1.11	0.46–2.70
	Unemployed (n=51)	**4.76**	**2.33–10.00****
	Baseline: full-time salary (n=660)	**1**	
Origin of the father (n=819)	Other EU country (n=51)	2.17	0.81–5.88
	Outside EU (n=146)	**3.70**	**2.08–6.67****
	Baseline: Belgium (n=622)	**1**	
Educational level of the father (n=819)	Vocational secondary school (n=60)	0.30	0.11–1.59
	Secondary school, first cycle (n=47)	0.20	0.04–1.12
	Secondary school, second cycle (n=329)	0.36	0.13–1.04
	Bachelor degree (n=213)	**0.17**	**0.05–0.57****
	Master's degree (n=136)	**0.30**	**0.09–0.99***
	Baseline: Primary school (n=34)	**1**	

CI: confidence interval; EU: European Union.

[a] For only six children the main vaccinator was other than well-baby clinic, paediatrician or general practitioner.

*p<0.05

**p<0.01

Table 5

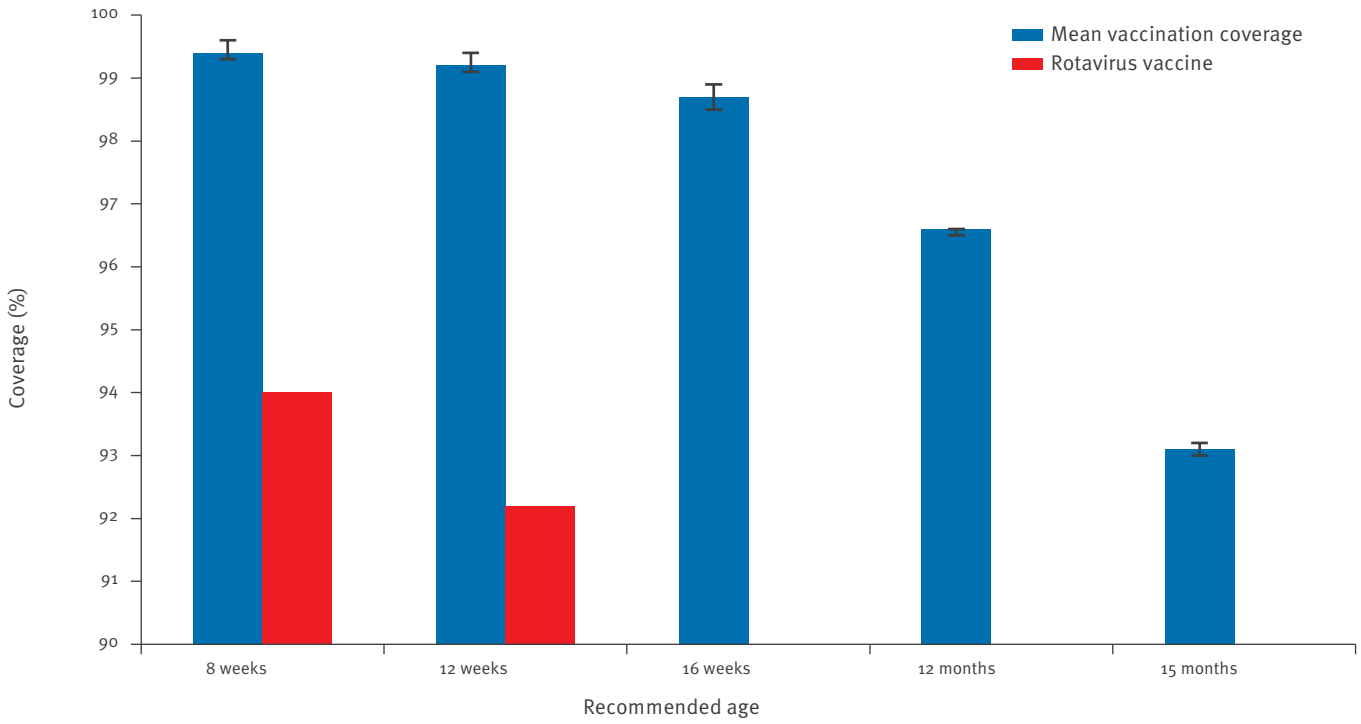
Predictive factors for having received an incomplete schedule for rotavirus vaccination (multiple logistic regression), Flanders, 2012 (n=874)

		Odds ratio	95% CI
Province (n=874)	Limburg (n=120)	**0.21**	**0.06–0.72***
	East Flanders (n=200)	**0.45**	**0.21–0.95***
	Flemish Brabant (n=146)	0.49	0.22–1.11
	West Flanders (n=182)	0.85	0.43–1.67
	Baseline: Antwerp (n=226)	**1**	
Rank in the household (n=874)	First child (n=76)	1.61	0.65–4.00
	Second child (n=304)	0.76	0.38–1.54
	Third child (n=113)	1.25	0.53–2.94
	Fourth child or younger (n=50)	**4.00**	**1.72–10.00****
	Baseline: only child (n=331)	**1**	
Mother's employment situation (n=869)	Part-time salary (n=213)	0.87	0.40–2.22
	Self-employed (n=27)	2.04	0.60–7.14
	Unemployed (n=211)	**2.56**	**1.35–5.00****
	Baseline: full-time salary (n=418)	**1**	

CI: confidence interval.
*p<0.05
**p<0.01

Figure

Comparison of vaccination coverage at the recommended age of rotavirus vaccine and vaccines offered free of charge, in children aged 18–24 months, Flanders, 2012 (n=874)



Note: Y-axis does not start at zero

were convinced that their child had received all the recommended vaccines, while two parents had no idea whether the vaccination status was complete or not.

After consulting the vaccination card, parents of the children with missing rotavirus vaccine doses were asked for reasons of incomplete vaccination. At this point, 22 parents (32%) still assumed that all doses had been administered but not documented, 18 parents (27%) could not think of any reason why the rotavirus vaccination schedule was incomplete, and 27 (40%) were aware of their child being unvaccinated; among the latter, the majority (n=18) chose deliberately not to do vaccinate their child. Reasons mentioned by the remainder included illness and missed appointments. Age restrictions for initiating and completing the rotavirus vaccination schedule were mentioned only once.

Factors related to vaccination status

Univariate analysis

The univariate analysis identified the following factors as significantly related to a lower probability of being fully vaccinated against rotavirus: living in the province of Antwerp, not attending day care during the first year of life, general practitioner as main vaccinator, three or more older siblings in the household, unemployed mother and/or father, and origin of mother and/or father outside the EU (Table 4). A monthly income higher than EUR 2,000 resulted in a higher probability of being fully vaccinated, as did a higher educational level of the father. Breastfeeding and educational level of the mother were not related to vaccination status.

Multivariate analysis

Since many of these characteristics are related, we examined these influencing factors through a multivariate approach. In view of the relation between maternal and paternal factors, we decided to retain only the maternal parameters. Previous coverage studies have shown that many influencing factors were related to the main vaccinator. Therefore, it was decided to exclude the latter.

The following factors were identified in a multiple regression analysis as being related to incomplete vaccination: living in the province of Antwerp, unemployed mother, and three or more older siblings in the household (Table 5).

Discussion

Since Belgium adopted the rotavirus vaccination early, using a co-financing policy, it represents an interesting opportunity to assess rotavirus vaccine uptake comparing with other recommended infant vaccines, free of charge. This study falls within the ambit of the 2011 conclusion of the Council of the European Union on childhood immunisation which emphasised the need for high quality national data on vaccine coverage rates [7,8].

The coverage rate for rotavirus vaccination for the infant population in Flanders born in 2010 exceeded 90%, four years after the introduction of the vaccine on the Belgian market and publication of the recommendation. This is a major increase compared with the coverage of 30% (for two doses of rotavirus vaccine) registered among children born in 2006, shortly after introduction of the rotavirus vaccine [4]. The pentavalent rotavirus vaccine was licensed and recommended for routine immunisation of infants in the United States (US) in February 2006, a couple of months before Belgium [9]. National coverage estimates on rotavirus vaccination coverage in the US were reported for the first time in the 2009 National Immunization Survey (NIS): 43.9% of the children born within two years of licensure had full coverage [10]. The most recent NIS in the US reported an increase in rotavirus vaccination coverage from 59.2% in 2010 to 68.6% in 2012 [11].

A coverage rate of 92.2% is very high for a vaccine for which the parents have to co-pay per administered dose, but still lower than the coverage (93–99%) achieved for other infant vaccines recommended in the National Immunization Programme (NIP) for the first year of life and offered free of charge by the government (Figure).

Besides rotavirus vaccination, the survey also covered other childhood immunisations included in the infant immunisation schedule in Flanders [12] for which we examined possible predictive factors for undervaccination. The observed differences between provinces in Flanders were only significant for rotavirus vaccination and not for other infant immunisations. Further looking into the Antwerp province revealed that the most urbanised district had the lowest coverage rates for rotavirus vaccination. This might indicate a risk factor related to urbanisation that could not be explored thoroughly using the characteristics that were collected during the interview.

The negative impact of a large number of older siblings on rotavirus vaccine uptake may partly be explained by the fact that rotavirus vaccines were not yet available at the time the older siblings received their infant immunisations, leading to decreased awareness among these parents. Logistical problems associated with large families may also have contributed to the lower vaccination coverage. Unemployment status of the mother has previously been identified as one of the socioeconomic factors related to an incomplete vaccination status for other infant vaccines in Belgium [6,16]. In the current survey, this was the case not only for the rotavirus vaccine but also for infant doses of the pneumococcal and measles-mumps-rubella vaccine [12]; there is therefore no solid evidence to argue that this could be related to the fact that parents have to co-pay for rotavirus vaccines.

Although the multivariate analysis did not identify any inequality that may have been introduced by the

co-payment system, one could question whether this is the most efficient way in terms of budget allocation. It has been calculated that fully funded universal vaccination would be at least 30% less expensive (if the coverage is 80%) and more cost-effective compared to the current situation, if a well negotiated vaccine price were achieved, e.g. through a tender system [17].

It is of utmost importance to complete the vaccination schedule once it is initiated. Only 2% of the children that received a first dose of rotavirus vaccine did not complete their schedule. The proportion of children who completed their vaccination series in Flanders is somewhat larger than the reported proportion based on US health insurance claims for under one year-olds, where 9% of the children immunised with the monovalent vaccine missed a final dose, and 16.6% of the children who received a first dose of the pentavalent vaccine did not complete their schedule [14]. In our study it was not possible to distinguish between vaccine brands; therefore we might have misinterpreted the completeness of the vaccination schedule, since two doses (considered as fully vaccinated in our study) might have been an incomplete vaccination schedule with Rotateq (needing three doses to be complete). However, the two-dose monovalent vaccine Rotarix has the highest market share in Belgium (>85%) [15]. A third dose was documented in 109 children (12.5%; data not shown) [12], which is in line with the market share of the pentavalent vaccine. Still, the possible overestimation of the completeness of the schedules may have led to an overestimation of the coverage.

If parents were aware that a rotavirus vaccine dose had been missed, the omission seemed to be a deliberate choice (based on the small number of parents in our sample). Further investigation is needed into whether this was related to the cost of the vaccine, to the low perceived risk of the disease or to practical barriers. However, the multiple regression analysis that corrected for several socio-economic characteristics found no association between an incomplete schedule for rotavirus vaccination and income of the family. For those children who did not complete their initiated schedule, illness was most frequently mentioned as a reason.

There is a decreasing trend in coverage with advancing recommended age for all infant vaccine doses including rotavirus vaccine (Figure) [12]. However, the latter has a lower coverage than the other infant vaccines at any time point, which could be due to the fact that rotavirus vaccines are not available free of charge at the vaccinators' sites; parents first need a prescription from the physician to purchase the vaccine at the pharmacy, so they may not have the vaccine with them when they take the child for administration of the other vaccines [12].

A recent study in Australia showed that the introduction of RotaTeq into the national immunisation programme increased the timeliness of the uptake of the third dose of diphtheria, pertussis and tetanus (DTP)-containing vaccine due to the strict dosing schedule of the rotavirus vaccine [18]. We did observe a positive trend between 2008 and 2012 in the timely administration of the DTP-containing vaccines in the first year of life [12,19]. This cannot be conclusively attributed to the influence of introducing the rotavirus vaccine, since timeliness has been a major topic in many campaigns in well-baby clinics, the main vaccinator in Flanders.

Considering the observed timeliness of rotavirus vaccination, compliance with the recommendations could be improved. The purpose of the recommended vaccination schedule is to protect every child as soon as possible and to minimise the period in which they are prone to infections. Any delay in vaccination can have a major impact, especially for diseases like rotavirus where multiple vaccine doses are required for protection [20] and disease risk in infancy is considerably high [21]. The majority of the vaccinated children received their second dose too late, although only eight children were vaccinated after the age of 26 weeks. The adherence to this upper age limit is of importance in view of the recent postmarketing surveillance data on the small increase in risk of intussusception (1–2/100,000 vaccinated infants) shortly after the first dose [22]. Considering the increased background rates of intussusception in older infants [23], catch-up vaccination is not recommended.

It is recommended to respect the minimum interval of four weeks between consecutive doses in order not to compromise the efficacy of the administered doses, otherwise this results in the necessity to re-administer the dose. Only six children received a second or third dose without respecting the recommended four-week interval between doses.

A selection bias may have occurred in this study due to a possible correlation between vaccination status and willingness to participate in this study. Although the refusal rate was low (7.6%), we cannot exclude overestimation of the coverage rates. It is unlikely that all parents who refused to participate in the study would have refused rotavirus vaccination for their child. But even if this were the case, the coverage rate would be acceptable at 85%. On the other hand, taking into consideration only documented vaccination history may have led to an underestimation, although every effort was made to obtain documented vaccination history.

Conclusion

The effectiveness of the implementation of rotavirus vaccination in Belgium has previously been demonstrated by the tremendous impact on the number of hospitalisations, with a reduction of 33% in the number of hospital admissions due to acute gastroenteritis during 2007–09, and on the number of laboratory-diagnosed cases, with a decrease of 61.4% in 2008 compared with the pre-vaccination period [5,15,24]. This

public health benefit could only be achieved because of the good performance of the rotavirus vaccination [15] in combination with a high coverage, although recent studies in Europe demonstrated that even a low rotavirus vaccine uptake may have significant effects on the disease burden [25,26].

Our results suggest that further efforts are necessary to identify those children that are not reached through the current vaccination strategies. Another issue for improvement is the timeliness of rotavirus vaccination. This was also emphasised by the World Health Organization in their most recent position paper, which calls for efforts to ensure the simultaneous administration of rotavirus vaccine with DTP-containing vaccines in a timely manner, in order to induce protection before natural rotavirus infection [22].

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Conflict of interest

NH: partly funded by Scientific Chair in Evidence-based Vaccinology sponsored by hand gift, Pfizer (2009-2014). PVD and KH: principal investigator of vaccine trials for several vaccine manufacturers.

Authors' contributions

TB, HT, TL, MR, KH, PVD were all involved in the design, coordination and data management of the study of vaccine coverage in Flanders in 2012, that covered different age groups. NH performed the logistic regression analysis

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