

Short Paper

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# Can Flanders resist the measles outbreak? Assessing vaccination coverage in different age groups among Flemish residents

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## Abstract

The Belgian strategic plan to eliminate measles contains several vaccination strategies including routine immunisation programmes and catch-up campaigns. A new expanded programme on immunisation-based survey (2016) assessed the uptake of the recommended measles–mumps–rubella (MMR) vaccine in three different cohorts: toddlers, adolescents and parents of toddlers. A two-stage cluster sampling technique was used to select 875 toddlers (age 18–24 months) and 1250 adolescents (born in 2000) from 107 municipalities in Flanders. After consent of the parent(s), 746 (85.2%) families of toddlers and 1012 (81.0%) families of adolescents were interviewed at home. Measles vaccination coverage was high at 18–24 months (96.2%) and 81.5% were vaccinated at recommended age. Toddlers who had two siblings or a non-working mother or changed vaccinator were more at risk for not being vaccinated. Coverage of the teenager dose reached 93.5% and was lower in adolescents with educational underachievement or whose mother was part-time working or with a non-Belgian background. Only 56.0% of mothers and 48.3% of fathers remembered having received at least one measles-containing vaccine. Although measles vaccination coverage in toddlers meets the required standards for elimination, administration of the teenager dose of MMR vaccine and parent compliance to the recent measles catch-up campaign in Flanders leave room for improvement.

In 1997, the World Health Organization (WHO) European Advisory Group on Immunization commissioned the preparation of a framework for the elimination of measles from the European Region [1]. Target dates for the elimination of transmission of endemic measles have been set and adjusted over time: by the end of 2020, the elimination of measles should be achieved in at least five WHO regions [2]. Despite many efforts, measles continues to spread within Europe, with large outbreaks in regions where immunisation coverage is below the threshold [3, 4].

The WHO strategy for measles elimination in the European region stipulates that a minimum of 95% coverage with two doses of a measles-containing vaccine should be achieved and maintained through high-quality routine immunisation services [5]. Additionally, measles vaccination should be offered to all population groups who are at risk for and susceptible to contracting the disease.

In 2003, a committee for the elimination of measles was set up in Belgium, with representatives from the three Belgian regions (the Flemish community, the French-speaking community and the region of Brussels). The role of the committee is to elaborate a national action plan and follow-up on the implementation of the activities [6]. The Belgian strategic plan contains several vaccination strategies including routine immunisation of infants and adolescents (second measles–mumps–rubella (MMR) recommended at 10–13 years) and catch-up campaigns with MMR vaccine targeting adults aged 20–45 years as they belong to the age cohort for which uncertainty concerning vaccination/immune status is highest. In Flanders, adults were targeted and offered free of charge MMR vaccine in 2015–2016.

In 2016, the uptake of the recommended measles-containing vaccines was assessed with an expanded programme on immunisation-based survey in three different cohorts in the Flemish community: toddlers, adolescents and parents of toddlers. Comparable surveys were conducted in 2005, 2008 and 2012 in order to have repeated measurements of coverage rates and assessments on risk factors for not being immunised [7–9]. This study was authorised by the National Privacy Commission and received approval on 8 March 2016 from the ethics committee of the University of Leuven (KU Leuven), in consultation with the ethics committee of the Antwerp University Hospital.

A two-stage cluster sample of 875 toddlers (born in 2014; age 18–24 months) and 1250 adolescents (born in 2000) was selected from the Flemish register of inhabitants. The clusters were proportionally distributed over 107 municipalities in Flanders. Selected families were informed by postal 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) language difficulties made it impossible for the interviewee to understand the questions (only a Dutch version of the questionnaire was available) or (iii) the interviewee no longer lived at the registered address. 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. A written informed consent was obtained from the parents for 746 (85.2%) toddlers and 1012 (81.0%) adolescents. All interviews took place between April and August 2016. Information on socio-demographic characteristics and documented vaccination history was recorded using a standardised questionnaire. The demographic and socio-economic characteristics of the participating toddlers and adolescents were compared with census data. In toddlers, there was a slight under-representation of single-parent families and part-time working parents and a larger proportion of mothers with a higher education and more frequent daycare use. In adolescents, socio-demographic characteristics of the sample matched the general population more closely.

Vaccination data of toddlers and adolescents were checked against the electronic Flemish vaccine registry (Vaccinnet), and missing data were retrieved from medical files of the general practitioner, paediatrician, well-baby clinics or school health care. We assessed the coverage of recommended vaccinations in toddlers and adolescents, including MMR vaccine and inquired about measles vaccination status among mothers and/or fathers of toddlers. For this latter cohort, we took into account both recall and documented history on measles vaccination.

Adherence to the recommended age of vaccination was assessed, by comparing the vaccination history of the child/adolescent with the recommended number of doses, the minimum age for each dose and the minimum acceptable interval between doses. Following the national guidelines, the first MMR vaccine dose had to be administered at the age of 12 months for the toddler cohort and 15 months for the adolescent cohort and we considered timely administration in case the vaccine was administered within 1 month after the recommended age. The teenager MMR vaccine dose had to be administered at the age of 10–11 years [10] with a minimum interval between the first and the second dose of 4 weeks [11]. Doses administered before the recommended minimum age were not subtracted from the coverage. 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.

Many studies have provided evidence that context-specific socio-economic and demographic characteristics of the parents are associated with the immunisation status of the child [12–16]. To identify the underserved populations and the reasons for non-vaccination in Flanders, predictive factors for incomplete vaccination were sought through multiple logistic regression in toddlers and adolescents and through univariate logistic regression in adults, as only few factors proved significant and a multiple regression model could not be applied. Since fathers' and mothers' characteristics were highly correlated, only the maternal factors were included in multiple logistic regression models.

Coverage for measles vaccination was high at 18–24 months (96.2%; 95% confidence interval (CI) 94.3–97.6) and comparable between the five Flemish provinces (range 95.2–97.1%). Only a minor proportion (0.4%) of the toddlers received a non-valid dose (i.e. before the age of 50 weeks), confirming the adherence of the vaccinators to the recommended minimum age. The majority of vaccinated toddlers (81.5%) were vaccinated at the recommended age, 16.7% received the vaccine more than 1 month after the recommended age. Toddlers who had two siblings, a non-employed mother or changed vaccinator were more at risk for not being vaccinated with an MMR vaccine (Table 1). Of note, having three siblings or more was not significantly associated with not being immunised against measles, which may be explained by the very small number of families with four or more children (8.4%) in the survey. A recent German study showed that there was a positive association of attendance at a childcare unit and a negative association with higher level of parental school education with measles immunisation status among toddlers [17]. It must be taken into consideration that social determinants are context-specific, some may be similar in countries with any income level, while others may be population-specific [18, 19].

In adolescents, the coverage of the teenager dose administered at the age of 10–11 years was 93.4% (95% CI 91.8–95.1). Among those with a teenager dose, 90.5% (95% CI 88.4–92.7) had a documented proof of the first dose of MMR vaccine. When considering two documented MMR vaccine doses, administered at the appropriate age, the coverage for complete measles vaccination among adolescents was 87.7% (95% CI 85.3–90.1%). Invalid doses were only observed for the first dose, administered before the age of 1 year (0.8%). The coverage was lower in adolescents who repeated at least one schoollyear or with a part-time working mother or a mother of non-Belgian origin (Table 1).

Among parents of toddlers, a total of 742 mothers and 736 fathers answered the question regarding their own measles vaccination status. The majority of the responding fathers (74%) and 56% of the responding mothers were born before 1985, the year of introduction of systematic measles vaccination into the childhood vaccination schedule. Almost half (46.5%) of fathers and 36.4% of mothers were not aware of their own immunisation status for measles. When parents claimed to be vaccinated with at least one MMR vaccine (48.3% (95% CI 42.9–53.7) of fathers and 56.0% (95% CI 50.9–61.0) of mothers), this was seldom confirmed by a vaccination document (for 5.9% of vaccinated fathers and 10.8% of vaccinated mothers). Only a minority of vaccinated parents (eight fathers and seven mothers) reported vaccination during the catch-up vaccination campaign for measles, specifically targeted at this age group. Univariate analyses identified that mothers with a non-Belgian origin and fathers with an origin outside the European Union were at risk for non-vaccination. Neither age nor level of education turned out to be significantly related to vaccination status.

The herd immunity threshold for the interruption of the circulation of measles varies according to the literature between 92% and 95% [20]. The WHO aims at establishing a coverage of 95% within the European Region. This is accomplished for the first dose among toddlers born in 2014 in Flanders, taking into account that the lower limit of the 95% CI is slightly below 95% and confirms the high vaccination coverage measured in 2008 and 2012 (see Table 2). Due to a possible selection bias, we cannot exclude overestimation of the coverage rates as there might be an association between vaccination status and

**Table 1.** Predictive factors for non-vaccination with MMR vaccine in toddlers and adolescents (odds ratio (95% CI), multiple logistic regression), Flanders, 2016

	Toddlers (one dose)	Adolescents (first dose)	Adolescents (second dose)
Vaccinator change			
Yes	<b>2.82**</b> (1.17–6.77)	NA	NA
<i>Baseline: no</i>	<i>1</i>	NA	NA
Number of children in household			
Two	1.81 (0.67–4.85)		
Three	<b>3.37**</b> (1.25–9.06)		
Four or more	0.49 (0.09–2.73)		
<i>Baseline: only child</i>	<i>1</i>		
First or only child			
Yes			0.96* (0.91–1)
<i>Baseline: no</i>			<i>1</i>
Mother's employment situation			
Part-time	1.32 (0.54–3.23)	0.97* (0.93–1)	<b>0.95***</b> (0.93–0.98)
Unemployed	<b>2.82**</b> (1.17–6.80)	1.02 (0.95–1.1)	1.02 (0.95–1.09)
<i>Baseline: full-time</i>	<i>1</i>	<i>1</i>	<i>1</i>
Study discipline adolescent			
Repeated 1 year	NA	<b>1.08***</b> (1.02–1.13)	<b>1.05**</b> (1.01–1.1)
Special education	NA	1.12* (0.99–1.27)	<b>1.09*</b> (0.99–1.19)
Other	NA	0.98 (0.85–1.13)	1.43* (0.95–2.14)
<i>Baseline: standard</i>	NA	<i>1</i>	<i>1</i>
Non-core family			
Yes		<b>1.14**</b> (1.01–1.29)	
<i>Baseline: no</i>		<i>1</i>	
Ethnicity of the mother			
European		<b>1.11**</b> (1.00–1.23)	<b>1.13**</b> (1.02–1.25)
Non-European		<b>1.11***</b> (1.04–1.19)	<b>1.08***</b> (1.02–1.14)
<i>Baseline: Belgian</i>		<i>1</i>	<i>1</i>
Educational level of the mother			
Secondary school, first cycle or lower			1.03 (0.98–1.08)
Bachelor/master			1.03* (0.99–1.07)
<i>Baseline: secondary school, second cycle</i>			<i>1</i>
Place of residence			
Towns and suburbs	2.02 (0.60–6.79)		
Rural area	0.50 (0.11–2.35)		
<i>Baseline: cities</i>	<i>1</i>		

Significant results in bold (\* $P < 0.1$ , \*\* $P < 0.05$ , \*\*\* $P < 0.01$ ).

Reference category in italic.

NA: not asked during survey.

Empty cells represent variables that were not included in the final model.

Pseudo  $R^2$  was calculated as goodness-of-fit measure (0.11 for toddlers, 0.07 for adolescents' first dose and 0.09 for adolescents' second dose).

willingness to participate. There are still opportunities for improvement regarding the timely administration of the MMR vaccine as the unvaccinated period remains too long for 16.7% of the toddlers. The coverage goal is not yet met for documented measles vaccination in adolescents, but with a reported coverage of the teenager dose of 93.4%, and an increase of 10% since

2005, the backlog is decreasing within this population [7, 21]. As the administration of the first and second MMR vaccine doses was in most cases 15 and 6 years, respectively, prior to the interview and electronic registration was not yet generalised, the coverage might be underestimated, especially for the first dose in this age cohort. The lack of documented vaccination

**Table 2.** Vaccination coverage of the MMR vaccine among different age cohorts in Flanders, 2005, 2008, 2012 and 2016 (% (95% CI))

Vaccine	Cohort	2005	2008	2012	2016
MMR1	Toddlers	94.0 (92.6–95.3)	96.6 (95.2–97.6)	96.6 (95.1–97.6)	96.2 (94.3–97.6)
MMR2	Adolescents	83.6 (81.4–85.8)	90.6 (89.0–92.2)	92.5 (90.9–94.1)	93.4 (91.8–95.1)
2MMR	Adolescents	74.6 (NA)	83.5 (81.2–85.8)	84.6 (82.3–86.9)	87.7 (85.3–90.1)
MMR	Parents	NA	NA	35.8 (NA) mother of toddler 31.0 (NA) father of toddler	56.0 (50.9–61.0) mother of toddler 48.3 (42.9–53.7) father of toddler

NA, not assessed.

MMR1: first dose of MMR vaccine.

MMR2: second dose of MMR vaccine.

2MMR: two MMR vaccine doses.

history is also observed for adults, which makes the results on vaccination coverage in this specific cohort less reliable as recall might induce either over- or underestimation of the actual immunisation status. Nevertheless, recall of measles vaccination within the scope of the recent vaccination campaign was very poor. Recent research has shown that sub-optimal vaccinated cohorts of young adults could delay the impact of elimination efforts. In combination with potential waning of vaccine-induced immunity among vaccinated people, this could lead to an increased outbreak risk [22].

An important limitation of this study lies within the selection of the study population as vaccination coverage assessment was restricted to children and parents officially living in Flanders and no information is given for asylum seekers and illegal immigrants. Outbreak investigation during a recent measles epidemic in Wallonia, Belgium, revealed that the disease occurred mainly among permanent residents from Central and Eastern European origin, characterised by frequent travel and movements. The majority of the cases were either unvaccinated or unaware of their vaccination status and even nosocomial transmission occurred through unvaccinated health care workers [23].

Belgium is not the only European country facing recurrent measles outbreaks due to inadequate vaccination coverage, and some other countries (e.g. France and Italy) are considering passing a law to enforce compulsory childhood vaccinations, but this strategy is not being considered yet in Belgium [24].

Although measles vaccination coverage in toddlers meets the required standards for elimination in Flanders, adherence to the recommendations regarding timely immunisation, administration of the teenager dose of MMR vaccine and parent compliance to the recent measles catch-up campaign leave room for improvement in order to achieve elimination of endemic transmission and avoid recurrent epidemics. This can be accomplished by discussing measles vaccination status during each health care-related contact, by emphasizing the importance of timely administration during each communication concerning immunisation and by implementing active reminder strategies towards parents of unvaccinated children [25]. Since 2015, the Flemish government has installed a special team that focuses on reaching target groups that remain underserved despite efforts from official health authorities. Advancing the recommended age of the second MMR dose might be considered as well, as it would reduce the susceptible period for children not responding on the first dose.

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