
Economic Costs of Measles Outbreak in the Netherlands, 2013–2014

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In 2013 and 2014, the Netherlands experienced a measles outbreak in orthodox Protestant communities with low measles–mumps–rubella vaccination coverage. Assessing total outbreak costs is needed for public health outbreak preparedness and control. Total costs of this outbreak were an estimated \$4.7 million.

During May 2013–March 2014, the Netherlands was affected by a large measles outbreak (1). The outbreak began in the center of the country in an orthodox Protestant community and spread mainly to regions with low vaccination coverage. Overall, the Netherlands has high measles–mumps–rubella (MMR) vaccination coverage, with >95% coverage for the first dose of MMR for children. However, some orthodox Protestant and anthroposophic communities opt out of childhood vaccination programs on religious grounds or on the basis of personal beliefs (2). In addition to the effects of disease on a society, measles outbreaks have economic consequences, including direct medical costs and productivity losses. Moreover, a measles outbreak demands a range of responses from the National Institute for Public Health and the Environment (RIVM) and municipal public health services (MHS). Assessing outbreak costs, including costs of response activities by public health authorities, can help in planning for future outbreaks and in optimizing allocation of public resources. Recent research on measles outbreak costs in industrialized countries is scarce and has addressed hospitalizations costs (3), costs of imported cases of measles (4–7) or small outbreaks (8,9). We assessed the economic costs of a large measles outbreak in the Netherlands.

The Study

All physicians and laboratories are mandated to report measles to MHSs in the Netherlands. Each MHS records

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patient information in a national database, which includes information on age, postal code, date of symptoms, complications, hospitalization, and source of infection. Notifications of measles cases were used to assess medical costs and productivity losses (online Technical Appendix, <http://wwwnc.cdc.gov/EID/article/21/11/15-0410-Techapp.pdf>). Information on additional serologic tests and extra vaccinations among health care workers in hospitals were obtained from a study on the implementation of measles guidelines for hospitals (online Technical Appendix). Information about vaccinations of infants and older unvaccinated children in response to the outbreak was retrieved from the national immunization register. We interviewed staff at MHSs and the RIVM to assess the amount of personnel time related to outbreak response activities (online Technical Appendix).

During the epidemic, 2,700 measles cases were reported, mostly among children 5–14 years of age (Table 1). In 329 patients, complications such as otitis media, pneumonia, and encephalitis developed. One child died from measles complications, and 181 patients were hospitalized. One patient with encephalitis spent 8 months in a rehabilitation clinic. Of patients who consulted a physician but were not hospitalized, 199 experienced complications, mostly otitis media (104 patients) or pneumonia (75 patients). Total estimated cost for direct health care was \$1,255,718 (mean \$465/case). An additional \$365,885 (\$136/case) was attributed to productivity losses and informal child care losses (online Technical Appendix Table 1). In 2013, most (85%) responding hospitals in the Netherlands offered a serologic test to employees to ensure that they were sufficiently protected against measles (online Technical Appendix). Employees identified as being at risk for measles infection were offered an MMR vaccination. On average, 80 serologic tests led to 63 vaccinations per hospital for a total estimated cost of \$222,203 (online Technical Appendix Table 2).

At the start of the outbreak, RIVM convened a national outbreak management team to discuss a strategy regarding targeted vaccination campaigns for infants living in communities with low vaccination coverage and for previously unvaccinated persons. A total of 6,652 infants received a complimentary MMR vaccination. Among children 18 months–19 years of age, 6,948 received an MMR vaccination during July 2013–March 2014. Costs for these vaccinations were \$299,840. During this outbreak, the RIVM also coordinated outbreak control, conducted enhanced surveillance, and responded to extensive media attention

Table 1. Estimated direct health care costs during measles outbreak, the Netherlands, 2013–2014*

Type of cost	Total no. patients	Unit cost, \$	Average health care utilization	Total cost, \$
Physician consultation				
Uncomplicated measles, no. visits	2,320	37.35	0.2	17,330
Uncomplicated measles, no. phone calls	2,320	18.07	0.1	4,192
Hospitalizations, no. cases	181	37.35	1.0	6,760
Other complicated measles, no. cases	199	37.35	2.0	14,865
Treatment for pneumonia in general practice, no. cases†	75	16.02	1.0	1,202
Length of hospitalization, d				
General ward	174	600	4.6	480,240
Intensive care unit	7	2,866	13.1	262,812
Rehabilitation	1	447	245	109,515
Serologic test results, no. cases‡				
Positive	139	21.37	1.0	2,970
Negative	854	21.37	1.0	18,250
DNA/RNA amplification, no. cases‡				
Positive	765	251.55	1.0	192,436
Negative	577	251.55	1.0	145,144
Total				1,255,718

*Costs are calculated in 2013 US dollars (\$). Total number of measles cases = 2,700. Total cost differs from sum of category costs because of rounding.
†IgM.
‡PCR.

(online Technical Appendix). Total costs for outbreak response activities by the RIVM were an estimated \$698,280 (\$259/case). In addition, we collected information from 6 MHSs that together had recorded more than half of all notified measles cases nationally. Their response activities included registration and processing of cases, vaccination activities, and advising of local authorities, professionals, and the general population (online Technical Appendix). Total estimated costs for all MHSs was \$1,852,470 (\$686/case).

The MHSs incurred most of the costs of the outbreak, followed by costs for hospitalizations (Table 2). Costs of outbreak response activities by the RIVM were also considerable. Costs classified as other medical costs (i.e., consultations with general practitioners), productivity losses, and costs for vaccination campaigns were among the lowest (Table 2; online Technical Appendix Table 3).

Conclusions

The measles outbreak occurring in the Netherlands during 2013–2014 was associated with substantial costs of ≈\$4.7 million (€3.9 million), or 0.0042% of overall health care costs (\$113 billion in 2013) in the Netherlands. The 2,700 reported measles cases during this outbreak resulted in an estimated \$1,739 per case. Outbreak management costs were the primary cost, probably because of demands for expert advice, response to extensive media attention, registration of notified cases, and more surveillance activities than usual.

Despite being substantial, the outbreak costs in our study are underestimated. Because of data limitations, we were unable to estimate normal human immunoglobulin costs, patients' traveling costs, or costs of vaccinations of adults or of long-term complications of disease. Also, reported cases in other countries have been linked to this

outbreak, including Canada, United States, and Belgium; associated costs for cases exported to other countries are not included in our calculations. Furthermore, surveillance systems are affected by a degree of underreporting; therefore, uncertainty exists about the “true” economic costs of disease (10). In a previous measles outbreak in the Netherlands, the estimated true number of measles cases was ≈10 times the number of cases reported in the surveillance system (11). Moreover, only 47% of hospitalized cases in the previous outbreak were reported (12). Applying these data to our results, the estimated total outbreak costs would be ≈\$0.9 million higher. Further research into the extent of underreporting in this outbreak is planned.

In Australia, the public health unit cost for responding to a single case of measles was \$1,701 (7), a similar amount to our results. In the United States, costs of containing an outbreak were estimated at \$6,180 per case. Additional US studies report that containment of a single imported measles case resulted in even higher costs per case (5,6). Explanations for the higher costs in the United States

Table 2. Distribution of costs of measles outbreak, the Netherlands, 2013–2014*

Category	Costs, \$	% of total costs
MHS	1,852,470	39.5
Hospitalization	852,567	18.2
RIVM	698,280	14.9
Production losses	365,885	7.8
Laboratory tests	358,801	7.6
Vaccination of children	299,840	6.4
Vaccination of health care workers	222,203	4.7
General practitioner consultation	44,350	0.9
Total	4,694,395	100

*Costs are calculated in 2013 US dollars (\$). Total cost differs slightly from sum of category costs because of rounding. MHS, municipal public health services; RIVM, National Institute for Public Health and the Environment, the Netherlands.

include more extensive contact tracing and higher medical care expenses.

The 2013–2014 measles outbreak posed considerable logistical challenges for MHS staff. Registration of reported cases contributed especially to the increased workload and costs created by this measles outbreak. To reduce this workload during a large outbreak, information considered to be critical for review could be collected for most patients, who usually recover within a few days or weeks, while more detailed information should continue to be collected for patients with complications or serious illness.

Measles substantially affects patients' quality of life (13) and their ability to perform their usual daily activities. Complications resulting from measles, such as pneumonia, encephalitis, and subacute sclerosing panencephalitis, sometimes occur a few years after the illness (14). Complications from measles also affect quality of life and incur high financial costs, as shown in the extensive rehabilitation care needed by a patient with encephalitis that resulted from this outbreak. In the Netherlands, because religious arguments affect vaccination rates (15), elimination of measles will be challenging. Measles outbreaks are expected to continue to cause substantial effects from disease and economic costs. To prepare for new outbreaks, medical costs, productivity losses, and containment costs should be considered.

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Technical Appendix

Additional Methods, Results, and Tables

Case Definition

The measles case definition used is based on the presence of clinical symptoms and laboratory confirmation of diagnosis. An epidemiologically linked case is defined as someone with a matching clinical presentation who had contact with a laboratory-confirmed case. The measles case definition used is consistent with that of the European Centre for Disease Control and Prevention (1).

Assessment of Outbreak Costs

Direct Medical Costs

Information on health care use regarding the number of general practitioner (GP) visits due to measles infection has been reported (2). In a previous Dutch outbreak, van Isterdael et al. (2004) estimated that 30% of the measles patients consulted their GP. We used this average number of consultations for patients without complications and assumed that 1 third of the patients contacted their GP by phone and the remainder by a GP visit (unpub. data, Tom Woudenberg, RIVM, Bilthoven, the Netherlands). In line with the Dutch health care system, we assumed that all hospitalized patients had consulted a GP once. Patients for whom complications developed (but who were not hospitalized) were assumed to have visited their GP twice. According to Dutch guidelines, apart from pneumonia, most measles complications reported by GPs (i.e., otitis media, dehydration, and upper respiratory infection) do not require further treatment (3). Medical costs were gathered from standard unit cost lists (4) and list prices available online (5). The unit cost per hospitalized day comprises treatment in hospital, treatment in an intensive care unit, and clinician consultation fees. Because the database of notified cases did not include negative diagnostic tests, we estimated the total number of diagnostic tests by applying the ratio of positive and negative diagnostic tests of the RIVM laboratory to all positive tests recorded in the national database.

All costs are expressed as U.S. dollars as of 2013. Euros were converted to US\$ by using data on purchasing power parity of the Organization for Economic Co-operation and Development: 1 US\$ = 0.83 euro.

Productivity Losses

Almost all notified measles cases were unvaccinated orthodox Protestants. Orthodox Protestants constitute a Calvinistic religious minority in the Netherlands who believe in predestination and divine providence. Their lifestyle is based on the scripture and religion, which play an important role in their daily life. Many of them reject vaccination for religious reasons. Because most orthodox Protestant women do not have a paid job and stay at home to take care of their children, productivity losses of women with measles were calculated as loss of informal child care (4,6). To calculate productivity losses for men, we used standard tariffs (mean, all ages) (4), adjusted for work participation in all age groups (7). We did not calculate productivity losses for parents taking care of sick children. The duration of productivity losses was calculated for the average duration of illness (i.e., 14 days).

Costs of Targeted Vaccination Campaigns

In the beginning of the outbreak, health care workers born after 1965 were encouraged to check their vaccination and measles infection status and complete their measles–mumps–rubella (MMR) vaccination if necessary (8). Data about serologic tests and extra vaccinations among health care workers in hospitals were obtained from a study on the implementation of measles guidelines for hospitals (unpub. data, Lydia Fievez, RIVM). In this study, 85% (69) of responding hospitals (81 of 88 hospitals in the Netherlands) offered a serologic test to employees.

In July 2013, parents of children 6–14 months of age who lived in communities with vaccination coverage <90% or who belonged to orthodox Protestant communities received a personal invitation for an early MMR vaccination. The normal schedule for MMR in the Netherlands is to receive the MMR-1 at 14 months and the MMR-2 at 9 years of age. Children 6–12 months of age received an MMR-0 vaccination, and those 12–14 months of age received an early MMR-1 vaccination. In addition, the municipal public health services (MHSs) offered an MMR vaccination to children and adolescents within the vaccination program up to 19 years of age if they had not yet received an MMR vaccination. To avoid including routine MMR-1 vaccinations at 14 months in the outbreak costs, we selected children who received their MMR-1 during the outbreak period who were >18 months–19

years of age. All vaccinations used in this study were recorded in the national immunization register (unpub. data; Praeventis database for registering vaccinations in the Netherlands). Vaccine price and administration costs were gathered from the Dutch Healthcare Authority (5).

Costs of Outbreak Response Coordination at the National Level (RIVM)

Personnel time spent on outbreak control and on investigating and processing the outbreak was also estimated. Given the limited resources, this reallocation of personnel time represents the loss of other production (i.e., opportunity costs). Personnel time of the RIVM was determined by hours allocated to surveillance, response, laboratory, and vaccination activities at the national level. This time estimate was obtained from personal interviews with the personnel in the relevant departments within RIVM. We calculated personnel costs by multiplying a person's salary tariff by the time spent on the measles outbreak.

Costs of Outbreak Response Coordination at the Regional Level (MHS)

To estimate the amount of personnel time associated with local outbreak response activities, we developed a questionnaire for semistructured interviews of MHS staff (i.e., doctors, nurses, and managers) in some of the regions with the highest number of notified measles cases. The interviews explored all MHS activities and the associated time investment of the personnel involved. All possible local reports and registries were collected for additional information. The estimated time investment of physicians, nurses, nursing assistants, managers, and communication employees involved in the outbreak were converted to costs by using an average salary tariff per hour of MHS staff. We calculated time and costs per notified case in these regions and extrapolated these estimates to all notified cases in the Netherlands.

Additional Results of Costs of Outbreak Response Coordination

Costs of Outbreak Response Coordination at the National Level (RIVM)

Four departments at RIVM were involved with the measles outbreak: the Centres for Epidemiology and Surveillance; Communicable Disease Control; Infectious Diseases Research Diagnosis and Screening; and Policy and Regional Support. During the outbreak, representatives of these departments participated in a weekly response meeting at which the current outbreak and national containment strategies were discussed. Technical Appendix Table 4 shows the total labor time and costs for all personnel involved. Total costs were estimated at \$698,280.

The interviewed MHS staff confirmed that measles response activities were time consuming, especially registration and processing of new measles cases in their region. On average, these activities required 2–3.5 hours per case. At the beginning of the outbreak, numerous internal staff meetings were held to organize regional response activities adequately. Vaccination activities were limited because the targeted group of orthodox Protestants is generally unwilling to accept measles vaccination. Of the different personnel categories, public health nurses spent most of their time performing outbreak response activities (Technical Appendix Table 5). Based on these data, the total cost for all MHSs was estimated to be \$1,852,470 (\$686.1 for each of 2,700 notified cases).

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Technical Appendix Table 1. Estimated indirect costs and productivity losses for men and women during measles outbreak, the Netherlands, 2013–2014*

Category	Sex	
	M	F
Adult cases, no.	100	109
Employment or provision of informal child care, %	72.3%	100%
Employment or provision of informal child care, h/wk	36.1	40.0
Productivity costs/h, \$†	42.67	16.42
Total productivity losses, \$†	222,740	143,145

*Productivity losses were calculated for 2 weeks (10 working days) as average duration of illness. Because orthodox Protestant women tend to stay at home taking care of their children, we calculated production losses of work absenteeism for men and production losses of informal child care provided by women.

†Production costs and losses are calculated in 2013 US dollars (\$).

Technical Appendix Table 2. Costs of targeted vaccination campaigns during measles outbreak, the Netherlands, 2013–2014*

Population/category of cost	Unit costs, \$	Costs and factors affecting costs		
		Hospitals, no.	Average no.	Total costs, \$
Health care workers				
Serologic test	21.37	69	80	117,962
Vaccination	8.33	69	63	36,211
Administration costs	15.65	69	63	68,031
Total				222,203
Children 6–14 mo		MMR-0, no.	Early MMR-1, no.	
Vaccination	8.33	5,238	1,414	55,411
Administration costs	14.76	5,238	1,414	98,184
Total				153,595
Children 18 mo–19 y			MMR-1, no.	
Vaccination	8.33		6,948	57,877
Administration costs 0–5 y	14.76		2,764	40,797
Administration costs 5–19 y	11.37		4,184	47,572
Total				146,246

*Costs are calculated in 2013 US dollars (\$). Total cost may differ from sum of category costs because of rounding. MMR, measles–mumps–rubella; MMR-0, extra MMR vaccination given to children 6–12 months of age; Early MMR-1, MMR vaccination given to children 12–14 months of age; MMR-1, MMR vaccination given to children 18 months–19 years of age.

Technical Appendix Table 3. Main cost categories of measles outbreak, the Netherlands, 2013–2014*

Category	Costs, \$	% of total costs
Outbreak management	2,550,750	54.3
Medical costs	1,255,718	26.8
Prevention (vaccination)	522,044	11.1
Production losses	365,885	7.8
Total	4,694,395	100

*Costs are calculated in 2013 US dollars (\$). Total cost differs slightly from sum of category costs because of rounding.

Technical Appendix Table 4. Labor time and costs for personnel involved in outbreak management at the national level (RIVM) during the outbreak of measles, the Netherlands, 2013–2014*

Department	Task	Labor time, h	Costs, \$
Disease control	Coordination of outbreak control and communication	2,730	300,723
Support	Organization of MMR-0 and MMR-1 vaccination campaigns	1,754	177,372
Surveillance	Analysis and reporting of outbreak data	996	118,257
Diagnostics	Advice and Interpretation of laboratory results†	846	101,928
Total			698,280

*Costs are calculated in 2013 US dollars (\$). RIVM, Ministry of Health, Welfare and Sport, the Netherlands; MMR, Measles–Mumps–Rubella. MMR-0, extra MMR vaccination given to children 6–12 months of age; Early MMR-1, MMR vaccination given to children 12–14 months of age; MMR-1, MMR vaccination given to children 18 months to 19 years of age.

†Costs of laboratory tests are presented in Table 1 of article.

Technical Appendix Table 5. Labor time and costs for personnel involved in outbreak management at regional level MHSs in measles outbreak, the Netherlands, 2013–2014*

Employee	Tariff, \$	Labor time per notified case, h	Costs per notified case, \$
Nurse	69	5.2	359.00
Physician	107	1.9	203.00
Manager	103	0.6	62.00
Communication employee	88	0.4	35.00
Nursing assistant	54	0.5	27.00
Total		8.6	688.00

*Costs are calculated in 2013 US dollars (\$). Total cost differs slightly from sum of category costs because of rounding.