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Short communication

Hospital outbreak of measles – Evaluation and costs of 10 occupational cases among healthcare worker in Germany, February to March 2017

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ABSTRACT

After treatment of an inpatient with measles, an outbreak occurred within the unprotected healthcare workers (HCW) of a regional hospital in Hesse, Germany in February and March 2017. Overall, 10 HCW contracted measles. Remarkably, none of the affected HCW had direct contact to the index patient. One nosocomial transmission to a patient occurred. The economic impact of the outbreak is estimated to approximately 700,000€.

Medical institutions play a major role in the management of measles outbreaks, since the risk of exposure as well as nosocomial transmission to vulnerable patients and HCW is very high. To avoid outbreaks it is essential to have an easily accessible documentation of the immune-status of all HCW. The role of occupational medicine in identifying and closing vaccination gaps is of particular importance.

1. Introduction

Measles is a vaccine-preventable disease with one of the highest basic reproduction numbers (R0 = 15–18) and a contagion- and manifestation-index near 100%. Thus, anyone without immunity acquired by either vaccination or prior infection will contract measles and develop the characteristic symptoms: rash and fever. Prior to the onset of rash Koplik spots, which are pathognomonic for measles, might appear on the buccal mucosa [1].

Back in 1998, the World Health Organization (WHO) had already proclaimed the goal to eliminate measles in Europe which had to be postponed several times [2]. Germany still struggles to reach the elimination goal for measles [3,4].

Recently, health-care facilities turned out to be major sites of acquisition of measles and numerous studies have shown that measles are transmitted from patients to health care workers (HCW) and from HCW to patients and colleagues [5–7]. The risk to contract measles has been estimated to be 2- to 19-times higher for HCW than for the general public [8].

Vaccinations for HCW are not mandatory in Germany. However, the "*Infection Protection Act*" with §23a regulates the use of data from vaccination documents and lab results of the immune status of HCW [9]. Despite this, data about the vaccination status are still not collected on a regular basis. The "*German Standing Committee on Vaccination (STIKO)*" at Robert Koch-Institute recommends one dose of MMR for HCW born after 1970 without vaccination, with only one vaccination in childhood or a vaccination status that is uncertain [10].

This article describes an outbreak of measles among HCW from February to March 2017 at a regional hospital in the German federal state Hesse.

2. Materials and methods: Chronology of the outbreak and measurements for controlling the outbreak

On January 31, 2017, a patient with laboratory confirmed measles was announced by a local health protection agency to hospital A (650 beds) for admission. Hospital A is one of three sites of a hospital composite being under one management. The other two sites in different cities (B and C) were not affected by the outbreak.

The patient (later defined as index case) was treated and cared for only by HCW with evidence of vaccination. During treatment,

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HCW wore personal protective equipment (coat, gloves, surgical masks).

Subsequently, one HCW fell ill with measles on February 13, 2017. The next day, a patient transport service employee from the logistic department got sick with measles. This resulted in the proclamation of an outbreak event and the installation of a crisis management group at the hospital [11]. Subsequently, the hospital was informed about eight more cases of measles among HCW.

3. Control measures related to HCW and strategy choice

Documentation of the immune status of HCW was scarce and divided into written files and an electronic database. The infection control team and the occupational health physician checked the available data; however, a reliable assessment of immunity to measles could only be given for less than 5% of the HCW. To ensure patients were only treated by measles-immune HCW, the following two strategies were therefore considered:

- Checking vaccination certificates, performing MMR-vaccination in case of insufficient and unclear immune status
  OR
- Determination of measles-IgG and vaccination in case of negative or equivocal IgG titer

As only few HCW had a vaccination card, the latter strategy was chosen to guarantee quick identification of measles-immune HCW.

According to German seroepidemiological data, HCW born before 1970 are considered to be immune by a likelihood of 95–98% [12].

The anti-measles IgM and IgG tests were performed with an EIA (Enzyme-Immuno-Assay) in an external lab. HCW were tested and grouped into one of three different categories of immunity against measles:

- >200 mIU/ml, **positive** IgG result, immunity assumed
- 150–200 mIU/ml, **equivocal** IgG result, immunity questionable
- <150 mIU/ml, **negative** IgG result, immunity not assumed.

Lab test results were available within 48 h. HCW with a negative or equivocal IgG-titer were offered a MMR-vaccination. This group was furloughed until either a positive IgG titer was demonstrated or the end of the outbreak was declared.

4. Control measures related to patients

To detect nosocomial measles infections and avoid future nosocomial transmissions, measles-IgG and -IgM were determined for inpatients: first the test was performed for individuals treated in the intensive-care unit, the maternity ward and oncology ward. Later on, all other inpatients were tested as well. Patients with a measles IgG < 200 mIU/ml were offered the MMR-vaccine (no contra-indication provided), and a protective reverse isolation was implemented. Patients with an equivocal or positive measles-IgM were isolated and screened daily for prodromal symptoms and rash or fever.

The costs of the outbreak were calculated by the finance and controlling department of the hospital on the basic of operative ratios and key figures.

5. Results

5.1. Characteristics of HCW

Overall, 1691 HCW are employed at Hospital A: 244 physicians, 769 nursing staff, 340 in other patient-related services and 338 in services not related to patients. The mean age was 42 years (17–69 years). Hospital B and C have 606 HCW, resulting in a total of 2297 HCW.

5.2. Serologic test results

Between February 16 and February 27, 2017, measles IgG were tested for 1443 (85.3%) of 1691 employees of hospital A. For 248 HCW (14.6%) the test was not performed due to absence during the time of the outbreak. Testing for measles-specific IgG showed a positive result for 95.6% of the staff of Hospital A (n = 1379/1443).

For 64 (4.4%) individuals, a negative or equivocal result was detected. For this group, immunity was not assumed. This group comprised five physicians, 29 nurses, 12 other professions with contact to patients and 18 staff members without contact to patients. The mean age was 35 years (19–61 years); five HCW were born before and 59 were born after 1970. Three HCW had formerly received one and eight employees had received two doses of MMR vaccine, while 53 were unvaccinated.

After the IgG test results were obtained, 62 HCW were vaccinated. Because two HCW were pregnant, they could not be vaccinated. Of the eight persons with two doses of MMR several years ago, seven were vaccinated and showed a sufficient increase in measles-IgG after two weeks.

Normally, controlling the measles-specific IgG to ensure a seroconversion after MMR vaccination is not necessary. However, to make sure that HCW with contact to vulnerable patients were immune to measles after vaccination, anti-measles IgG was controlled for the duration of the outbreak.

Considering the ongoing outbreak in the area, anti-measles IgG was also determined for HCW at the other two hospital sites (B and C). Overall, 83.7% of the staff (n = 1923/2297) were examined; 374 HCW were absent during the testing phase. Testing ~~of~~ these individuals was scheduled before resumption of work.

The immune-status of the HCW is shown in Table 1. It demonstrates a clear lack of immunity within the age group born after 1970; measles IgG was negative or uncertain for over 8% of this group (Table 1).

5.3. Measles infection among HCW

During the outbreak, 10 HCW of hospital A contracted measles. The infection was confirmed serologically by IgM detection (n = 6) or by PCR (n = 4), based upon the case definitions of the Robert Koch-Institute and the European case definition [13,14]. Two of the infected HCW had to be treated as inpatients. Age, occupation and vaccination status of these individuals are summarized in Table 2. Remarkably, none of the affected HCW had direct contact to the index patient. Only a cleaner had worked in the examination room 2 h after the index case had left. The index patient was treated on an internal medicine ward on the third floor and was not taken to external examinations. None of the afflicted healthcare personnel had contact to that floor. There were no meetings, conferences or ward rounds detectable to explain the infection.

5.4. Measles infections among inpatients

From January 31 to March 12, 2017, 7 inpatients with a confirmed measles infection were treated in hospital A. In 6 cases, the infection occurred prior to hospital admission. One patient was transferred to and back from another hospital; thus, the measles infection in hospital A could not be safely excluded and a nosocomial transmission was assumed. This inpatient showed a speedy recovery and no complications. By implementing the aforementioned measures to protect the patients in hospital A, transmission to vulnerable patients could have been prevented.

Table 1
Measles immune status of HCW of Hospital A, B and C (n = 1923/2297; 83.7% of the HCW were tested).

Age	Up to 20 yrs n = 48	21–30 yrs n = 366	31–40 yrs n = 383	41–47 yrs n = 307	>48 yrs n = 819	∑ n = 1923
Immunity assumed (IgG > 200 IU/ml)	91.7% (44/48)	91.8% (336/366)	91.6% (351/383)	97.4% (299/307)	99.3% (813/819)	1843
Immunity uncertain (IgG 150–200 IU/ml)	0	2.2% (8/366)	1.8% (7/383)	0.7% (2/307)	0.1% (1/819)	18
Immunity not to be assumed (IgG < 150 IU/ml)	8.3% (4/48)	6.0% (22/366)	6.5% (25/383)	2.0% (6/307)	0.6% (5/819)	62
Percentage of HCW with uncertain or no immunity	8.3%	8.2%	8.4%	2.6%	0.7%	4.2%

Table 2
Laboratory confirmed measles cases among HCW (sex, age, profession, onset of rash, former vaccinations) of hospital A (n = 10).

♂/♀	Age (yrs)	Profession	Onset of rash	Measles vaccination
f	21	Nurse	Feb 06, 2017*	2×
m	33	Physician	Feb 13, 2017	None
f	40	Nurse	Feb 13, 2017	None
m	34	Nurse	Feb 13, 2017	1×
m	49	Patient transport service employee	Feb 14, 2017	None
f	27	Nurse	Feb 15, 2017	None
m	32	Cleaner	Feb 16, 2017	None
f	44	Nurse	Feb 16, 2017	None
f	31	Physician	Feb 17, 2017	None
f	42	Nurse	Feb 17, 2017	Questionable

* No measles PCR analysis was performed for this HCW. In case this HCW was infected by the index patient, the incubation period as well as the duration of the measles rash appeared to be much shorter than usual, similar to previous observations [23].

5.5. Molecular epidemiology

In Germany, all suspected or confirmed cases of measles have to be reported to local health authorities who pass on the data to the National Reference Center for Measles, Mumps and Rubella (NRC MMR) in Berlin. Local health authorities in Hesse reported 76 cases of measles in 2017 [15].The NRC MMR received 45 submissions from the Lahn-Dill-District (LDD) in which hospitals A, B and C are situated, 24 measles infections were lab-confirmed. In 20 cases, genotyping was possible and revealed the variant D8-4807, which is endemic in Southern Asia. During the same time period, several other D8-variants were circulating in Hesse (D8-4808, D8-4813, und D8-4221), but these did not contribute to the outbreak in LDD. The nosocomial transmissions in hospital A were caused by a single imported variant (Fig. 1).

5.6. Expenses related to the outbreak

After the end of the outbreak was declared, a calculation of the economic impact was performed (Table 3). The economic loss amounts to approximately 700,000€. Most of the deficit is related to suspension of the personnel without immunity and the decrease in patients during the outbreak and in the following weeks. Performing the serology for almost 2000 HCW contributed to only 5% of the expenses.

6. Discussion

This report describes a measles outbreak in a German hospital that could have been prevented. To protect non-immune patients from measles, vaccination of the HCW is of utmost importance. To guarantee immediate ability to act in cases of suspected measles infection admitted into hospitals and other medical facilities, the knowledge of the occupational health physician about the vaccination status of all HCW is indispensable.

A recent study calculated that if the vaccination coverage drops by only 5%, a threefold increase in measles cases will be noticed [16]. Due to the high contagiousness of measles, medical facilities and their employees play a critical role in preventing or promoting the transmission of the virus [17–19].

It is still a matter of debate in Germany whether one or two doses of the MMR-vaccine are sufficient to protect adult HCW and moreover whether IgG tests must be performed on HCW involved with vulnerable patient groups. With respect to vaccine efficacy being approximately as high as 95% and the urgent need to particularly prevent and interrupt nosocomial measles virus transmission, the recommendation of 2 doses of the MMR vaccine for this group seems more appropriate and should be discussed. It still needs to be discussed whether wearing a surgical mask covering nose and mouth is sufficient or whether a FFP-2-mask/N95 respirator should be worn [20,21].

These questions must be addressed in the process of preparing for an outbreak and balanced in a risk analysis involving occupational medicine, management and hospital hygiene.

In a retrospective overall assessment, it was impossible to prevent this outbreak, because a relevant amount of HCW was unvaccinated. At the beginning of the outbreak, data of the measles immune status could only be determined for less than 5% of the HCW. Therefore, the IgG detection became necessary; otherwise it would not have been possible to identify personnel immune to measles fast enough. Alternatively, the immediate vaccination of all HCW could have been performed.

Lack of protection against measles correlated with the age of the employees: of all tested HCW born after 1970, 8% had a negative result for measles IgG. In contrast, only 0.8% of those born before 1970 showed a lack of anti-measles IgG. This finding indicates that closing gaps with respect to measles immunity is especially important for the age group born after 1970.

The ten HCW, who contracted measles during this nosocomial outbreak, were predominantly unvaccinated (Table 2). One HCW was one time and one HCW was two times vaccinated. Primary vaccination failure coincides with the lack of seroconversion and is mostly related to the cold chain being interrupted or to faulty application of the vaccine. Cases of secondary vaccination failure are

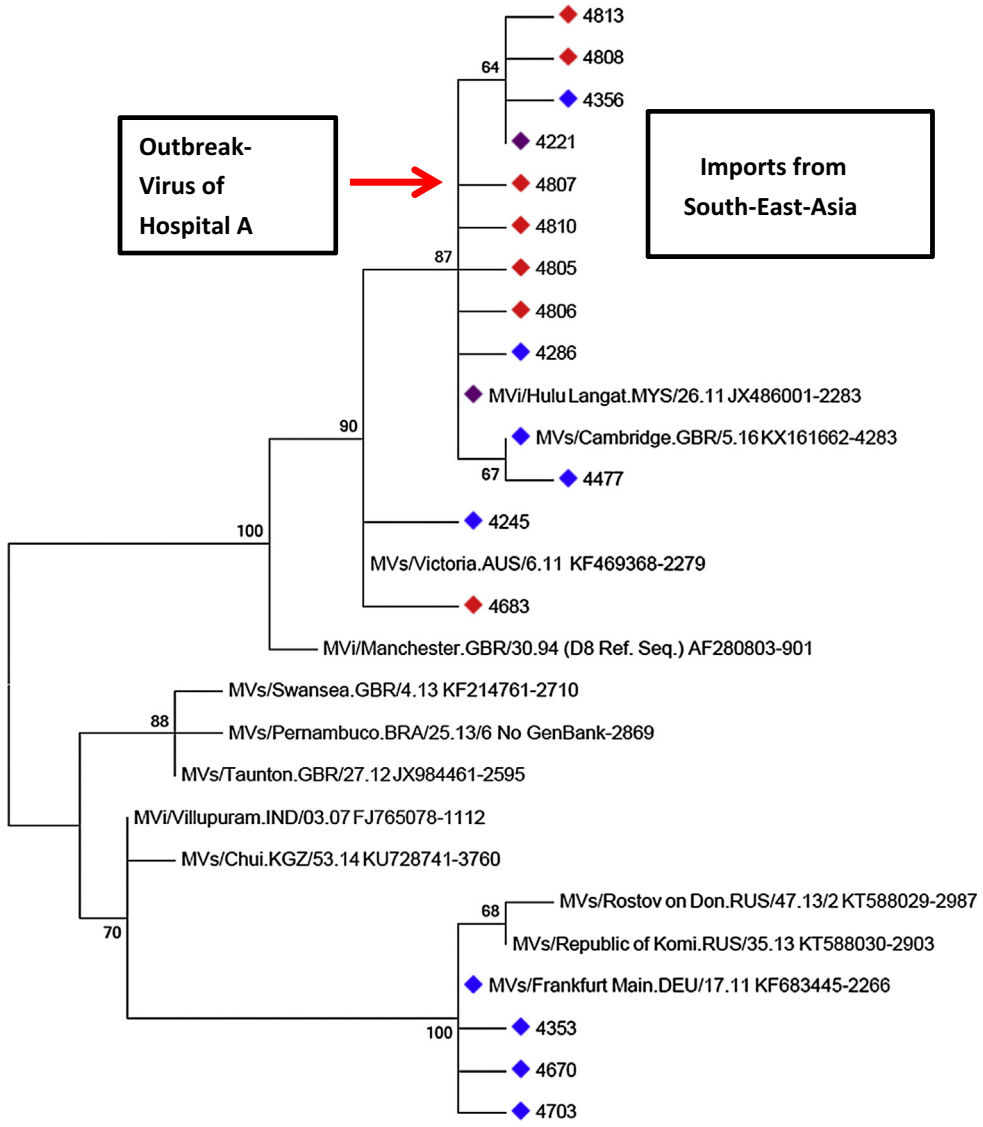

Fig. 1. The figure shows a phylogenetic analysis of the measles viruses detected in Hesse in 2016 (marked in blue) and 2017 (red), all belonging to genotype D8. The arrow indicates variant 4807, which was responsible for the nosocomial outbreak. The other variants circulated in Hesse before and during the outbreak but did not contribute to the transmission chain in hospital A. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Table 3
Calculation of costs.

Factor	Cost	%
Serological tests, vaccinations, other material costs	30,000€	4.3
• Medical leave of HCW who had contracted measles	215,000€	30.7
• Leave of absence of the unprotected HCW due to furlough		
• Leave of absence of HCW born after 1970 until serology test results were available		
Loss of revenues from patients whose admission had to be postponed or did not come at all, calculated on the expected mean gains of the three proceeding years	455,000€	65.0
Total	700,000€	100

observed with waning titers and increasing time periods since the last vaccination. Due to the overridden but nevertheless preexisting immunity, measles cases among twice-vaccinated individuals with documented secondary vaccine failure shed measles virus only for a short time period and with a reduced virus load. Normally, they are thus less infectious than cases with a primary infection [22].

An alternative explanation for the infection chain would be a measles infection of HCW no. 1 (nurse, 21 years old) independent of the index patient. This could also explain the subsequent cases of measles of the other HCWs, none of whom had contact to the index patient. This point was intensively discussed during the measles outbreak. Unfortunately, no measles PCR analysis was performed for this HCW. In case this HCW was infected by the index patient, the incubation period as well as the duration of the measles rash appeared to be much shorter than usual, similar to previous observations [23]. However, the serologic data showed solid signs of a measles reinfection.

Checking, documenting and completing the immune status with respect to vaccine-preventable communicable diseases are classical tasks of occupational health physicians in health care [10]. However, data about the translation of the STIKO recommendation into daily routine in German hospitals are scarce. The description of this outbreak should raise the awareness of all key players involved in health care to administer missing vaccines to HCW as soon as possible to prevent the transmission of measles virus and other highly contagious vaccine-preventable diseases

to their patients, relatives as well as colleagues. Moreover, the consequences, e.g. costs and loss of reputation, are economically relevant for hospital managements. Being able to identify immune HCW is an essential requirement for preventing outbreaks and protecting the health of patients and personnel in medical institutions and to restrict the economic costs of an outbreak.

Conflict of interest

Ute Hiller and Norbert Köneke: No conflict of interest.

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