Measles outbreak in a migrant laborer population in the wake of COVID-19 pandemic: Kathmandu, Nepal, 2020

Biplov Adhikari (biplov.adhikari.91@gmail.com)
Mulpani Primary Health Center
https://orcid.org/0000-0001-7773-9792

Sauharda Singh Karki
Mulpani Primary Health Center

Amrit Devkota
Mulpani Primary Health Center

Rahul Thakur
B P Koirala Institute of Health Sciences

Nabina Karki
Shahid Gangalal National Heart Centre

Shyam Sundar Budhathoki
Imperial College London

Short Report

Keywords: measles; outbreak; factory; migrant laborers; supplementary immunization activity; COVID-19

DOI: https://doi.org/10.21203/rs.3.rs-36529/v1

License: © This work is licensed under a Creative Commons Attribution 4.0 International License.  Read Full License
Abstract
We describe a measles outbreak in migrant laborers working in a carpet factory in Kathmandu, the capital of Nepal. The outbreak occurred during the nationwide lockdown enforced to contain the COVID-19 pandemic and 2 weeks after the Supplementary Immunization Activities done for measles elimination. We included all the patients from the factory presenting to Mulpani Primary Health Centre, Kathmandu, Nepal with acute febrile rash illness. Recovered patients with history of fever and rash within the defined outbreak period with a clear epidemiological linkage were also included. Laboratory confirmation was done by detection of immunoglobulin M (IgM) in serum samples against the measles virus via enzyme-linked immunosorbent assay (ELISA). We compared attack rates (ARs) between those less than 5 years and 5 years or older. We identified 11 case patients ranging from 7 months to 27 years of age (3 below 5 years of age); rash onsets were from 28 March-20 April 2020. All case-patients were laborers who had immigrated to Kathmandu from rural parts of the country. We sent serum samples of 7 patients for laboratory confirmation; 5 patients tested positive. The remaining four patients had a clear epidemiological linkage. The average attack rate was 30.5% with no significant difference between attack rates among the <5 years and the ≥5 years reported as 37.5 and 28.5 respectively. Migrant population from rural regions with poor outreach of essential health services like vaccination can act as pockets of measles susceptible individuals if not measles reservoirs. The squalid conditions in which the migrant laborers live-in can also compound the risk of outbreak in such populations. It is prudent to address the vaccination status of such population and timely correct their vaccine status if unvaccinated in order to meet the goal of measles elimination by 2023.

Background
Measles is a highly contagious vaccine-preventable febrile rash illness caused by the measles virus of the Paramyxoviridae family(1). A highly contagious, yet a vaccine-preventable disease, measles has been a leading infectious cause of morbidity and mortality across the world; close to 110,000 deaths were reported in 2017. New cases continue to be reported even from developed countries with high vaccination rates(2).

A total of 170 countries reported 112,163 measles cases to the World Health Organization (WHO) in 2019, a 300% increase compared to 2018(2). The data shows a soaring number of cases for 2 consecutive years. The South-East Asian and Western Pacific Region saw an increase in the number of measles cases by 40%(2). In Nepal, a low income country in Southeast Asia, there were 430 confirmed cases in 2019. And as of April 2020, 320 confirmed cases have been reported(3).

Floating populations like migrant laborers and refugees have poor access to health facilities including vaccination and live in poor, squalid conditions(4). They are highly susceptible to infectious diseases and are frequent harbingers of outbreaks. These mobile populations whose vaccination status is difficult to ascertain can also introduce disease into their destination communities. Measles elimination has been difficult to achieve partly due to such populations who travel in search of jobs or safety. Mostly a disease of children, a measles outbreak in such population is represented by a more homogenous distribution across the age groups(5).

Measles elimination, defined as the absence of endemic measles transmission in a country for ≥ 12 months, has been a difficult task for countries with weak health systems like Nepal(6). Following the introduction of the Measles-Rubella (MR) vaccine, Nepal along with other member states of the WHO Southeast Asian Region (SEAR) had aspirations of eliminating measles by 2020, but with more cases being reported, the plan has been postponed to 2023(7). As of today, 5 out of 11 countries in SEAR have achieved measles elimination(8).

Despite a reduction in the number of confirmed measles cases by 98% as compared to the year 2000, 5 confirmed measles outbreaks were reported in 2018 in Nepal(9). We describe a measles outbreak in a carpet factory among the families of domestic migrant laborers in Kathmandu, the capital of Nepal, 2 weeks after the completion of Supplementary Immunization Activities at the local administrative level during the nation-wide lockdown enforced to contain the COVID-19 pandemic.

Methods
Case Definitions
We defined a clinical case of measles as per the WHO definition as any person with fever, and generalized maculopapular (i.e. non-vesicular) rash, and either cough, coryza, or conjunctivitis(10). Laboratory confirmation was done by detection of measles-specific immunoglobulin M (IgM) with enzyme-linked immunosorbent assay (ELISA). Any case which fulfilled the clinical case definition of measles but was not completely investigated was classified as a clinically-confirmed case. Any case that lacked serological evidence of measles despite complete investigation was discarded. A case that met the clinical case definition of measles and was linked epidemiologically to a laboratory-confirmed or another epidemiologically-confirmed case of measles was classified as an epidemiologically confirmed case(11).

As per the guidelines for Nepal, we defined a confirmed measles outbreak as the occurrence of 3 or more confirmed measles cases in a health facility in a month(11). The outbreak period was defined as starting from 2 maximum incubation periods (42 days) before the rash onset of the first-identified case-patient through 2 maximum incubation periods after the rash onset of the last case-patient (11 February 2020–8 June 2020)(12).

Laboratory Testing

We collected the serum samples at the Mulpani Primary Health Centre, Kathmandu, Nepal and sent the samples to the National Public Health Laboratory (NPHL), in Kathmandu, for serologic testing. Serum samples were tested by enzyme-linked immunosorbent assay (ELISA) for the detection of immunoglobulin M (IgM) against the measles virus (Enzygnost Anti-measles Virus IgM, Dade Behring, Marburg, Germany)(13). All testing was completed at the National Public Health Laboratory, the only National Reference Laboratory under the Ministry of Health and Population in Nepal. NPHL is accredited by the WHO and is part of the Global Measles Laboratory Network(13).

Statistical Analysis

We performed descriptive analyses of categorical and continuous values that were obtained after filling the epidemiological case sheets for patients with their due consent. We report results for categorical values as proportions or frequencies and results for continuous values as medians or range. We calculated attack rates (AR) and compared them among those below 5 years of age and those who were 5 years or older. Distinction at 5 years was used because SIAs vaccinate children below this age. ARs were calculated as the number of confirmed measles case-patients divided by corresponding populations. We compared ARs across the two groups using Fisher exact tests. Analyses were performed using IBM SPSS version 20. Statistical significance was defined as a 2-sided $P$ value < 0.05.

Outbreak Setting

Kageshwori-Manohara municipality is one of the 11 municipalities in Kathmandu district. Located north-east of Kathmandu metropolitan city, this municipality is divided into 9 wards. Ward no. 6, where the carpet factory is located, has 2467 households with a total population of 11742(14).

The carpet factory had a total of 36 people including 8 children below 5 years of age living and working within its premises at the start of the outbreak. All the workers were migrants from various rural districts of Nepal. The factory had a steady turnover of workers. During the day, the workers came together in a hall where the weaving machines were kept. They slept in small huts made as satellite units to the big hall. A total of three huts with 9 rooms, each room of around 36 square feet, housed the workers and their families. Beds, utensils, and lavatories were shared. While the main working hall was spacious, the living quarters were overcrowded(15). Each person occupied an average of 10.125 square feet of the floor space of living area.

Detection

On the 6th of April, 2020, 3 patients, aged 11, 18, and 20 years were brought to the emergency department of Mulpani Primary Health Centre, Kathmandu with complaints of fever with rashes across the body and cough. All the patients were currently working at the carpet factory and had immigrated to Kathmandu from Rautahat, a district in the southern plains of Nepal. The patients had a history of contact with a person, their sibling, who had a similar illness and had now recovered. They had all arrived at the factory 3 months before the onset of the rash. After a detailed history and physical examination, we sent serum samples of all three
patients to the National Public Health Laboratory for measles confirmation. Two out of the three patients tested positive for measles-specific IgM by ELISA.

The index case had been working and living in the factory for 3 months before developing the acute febrile rash illness. The index was symptomatic for 6 days. Since the maximum incubation period for measles is 21 days, we inferred the index case had contracted the disease from within the community.

Response

We managed all the patients supportively until all their symptoms subsided. All patients received 2 age-appropriate doses of Vitamin-A. We obtained information regarding demographic characteristics, vaccination status, clinical complaints and signs, and outcomes of case-patients through face-to-face or telephone interviews.

Immediately after the presentation of the first three cases, we visited the carpet factory to search for more cases. We were able to identify the index case on the first visit. However, no new cases were found during the visit. We notified the various responsible authorities including the District Health Office of Kathmandu, the WHO-IPD office, the health section of Kageshwori-Manohara municipality, and local administrative and security authorities. The inhabitants of the factory were asked to remain indoors. All the residents of the carpet factory were vaccinated with a single subcutaneous dose of the MR vaccine.

Active surveillance was done through phone calls to the factory each day. We mobilized the Female Community Health Volunteers (FCHV) of Ward no. 6 to go door to door searching for people with an acute febrile rash illness. FCHVs are the indispensable bridges between health personnel and the community. They are aware of any health issues in the community at household and individual levels. FCHVs were pivotal in our active surveillance and ensuring its validity(16).

The municipality put out notices regarding the outbreak of measles and its signs and symptoms; radio programs were broadcasted asking people to seek immediate medical attention upon having suspicious symptoms. We called other facilities within the vicinity of the municipality to ask if they had received similar patients. We went through patient registers of other government health facilities inside the municipality searching for cases that may have been overlooked.

We convened a meeting of the rapid response team once the outbreak was confirmed. A prompt outbreak response immunization was carried out in the ward where the outbreak was recorded. A total of 2658 children from 6 months to 15 years of age were vaccinated in a bid to contain the outbreak on the 4th of May, 2020. FCHVs were again called upon to inform the community regarding the single-day outbreak immunization program. They were able to disseminate the information in a single day and worked tirelessly along with our vaccinators to provide the MR vaccine to a huge turnout.

Despite an extensive search for the course of the outbreak duration, the source of the infection could not be found.

Results

Patient Characteristics

We identified a total of 11 cases with acute febrile rash illness. The rash onset duration was from the 28th of March to the 20th of April, 2020 [Figure 1].

The median age was 18 years (range, 7 months to 27 years); 6 (55%) were female. In the 6 months to 5 years group all the 3 cases were females. [Figure 2]. All the patients were migrants from outside the municipality, 10 (90%) were from outside Kathmandu district. The districts of origin for the patients were Rautahat (4), Sindhuli (3), Makwanpur (1), Chitwan (1), Kavrepalanchowk (1) and Kathmandu (1). None of the patients were fully immunized.

All patients reported fever and rash. Cough was reported by10 (90%) cases; lymphadenopathy was observed in 7 (63%) and Koplik spots in 4 (36%) [Figure 3].

We sent a total of 7 serum samples to the NPHL for serologic testing. Five out of the 7 serum samples tested positive for Measles-specific IgM. Thus, 5 cases were classified as laboratory-confirmed cases and 2 cases were discarded. Since a clear
epidemiological linkage could be identified in the other 4 patients whose serum sample collection was not possible, we classified them as epidemiologically-confirmed cases of measles as per the WHO guidelines(11).

Amongst the cases, 2(18%) patients required hospital admissions due to severity of the symptoms. Complications were not observed in any of the cases. [Table 1].

Only 1 case-patient who was 15-months of age was vaccinated with a single dose of MR vaccine. This case-patient was unable to receive a timely dose of MR2 following the disruption of RIs due to the lockdown enforced to contain the COVID-19 pandemic. A 6-month-old case-patient who was not eligible for vaccination was classified as 'not applicable'. In the rest of the case-patients, a clear history of immunization could not be ascertained and thus, were labeled to have an 'unknown' vaccination status [Table 1].

Table 1
Hospitalization requirement and the Vaccination status of Patients (n = 11)

| Variables                  | n (%)          |
|----------------------------|----------------|
| Hospitalization Required   | 2 (18.18)      |
| Not required               | 9 (81.82)      |
| MR Immunization status     |                |
| Fully Immunized            | 0              |
| Partially Immunized (single dose) | 1 (9.09) |
| Unknown                    | 9 (81.82)      |
| Not applicable             | 1 (9.09)       |

The attack rate for children below 5 years of age was 37.5%, and that for those ≥ 5 years was 28.5. The total attack rate was 30.5.

No statistical significance was observed between attack rates between the age groups of < 5 years and ≥ 5 years [Table 2].

Table 2
Attack rates compared across age groups.

| Age Group | Population | Measles Cases | Attack Rate (%) | Age Group | p-valuea |
|-----------|------------|---------------|-----------------|-----------|----------|
| < 5 years | 8          | 3             | 37.5            | < 5 years | 0.678    |
| ≥ 5 years | 28         | 8             | 28.5            | ≥ 5 years |          |
| Total     | 36         | 11            | 30.5            | Total     |          |

aFisher’s exact test

Discussion

All the case-patients in our study were domestic migrant labor population and their family. The majority (82%) had an unknown vaccination status. The Government of Nepal mandates the vaccination of all children with two doses of MR vaccine, the first dose (MR1) at 9 months and the second dose (MR2) at 15 months of age, as per the National Immunization Program(NIP) through Routine Immunizations(RI)(17). In its quest to eliminate measles, Nepal has been conducting supplementary immunization activities (SIA) where children between 9 months to 59 months are vaccinated with a single dose of MR every 2 years(18). The immunity conferred by vaccination against measles is considered to last for at least 20 years(19).

Since their introduction in 2013 and 2015 respectively, the coverage of MR1 and MR2 vaccine was 81% and 66% in 2018(9). A coverage of over 95% is required for measles elimination(9). The Nepal Demographic Health Survey (NDHS) of 2016 showed that 22% of children from 12–23 months were not fully immunized and 1% received no vaccination at all(20). Only 43% of the children received age-appropriate vaccination(20). The percentage of children of the same age group exempt from complete immunization was 13% according to NDHS of 2011; 3% of the children had not received any vaccination (21). Given the increasing number of cases and poor coverage of the measles-containing vaccine, more exercise is required to eliminate measles by 2023.
Kageshwori-Manohara municipality had MR1 vaccine coverage of 106% in 2019, the highest coverage among the municipalities in Kathmandu District. This percentage purports that apart from achieving the complete vaccination of the target population, additional children were also immunized, mostly immigrant children. This high vaccination coverage at an early age also helps to explain the workings of herd immunity to contain the disease as no cases were native to the community (22).

Results from this report show very high attack rates in the people living inside the factory. A study of unvaccinated children in Bajura district of Nepal too showed a high attack rate among unvaccinated children (23). All of our case-patients, immigrants without the certainty of full immunization, showed high susceptibility to the disease. The districts of origins of our case-patients have low coverage of the MR2 vaccine (9). Since no cases were from the local population, a population with high vaccination coverage, our report highlights the pertinence of the MR vaccination.

This outbreak report is unique in the sense that the measles outbreak occurred in an urban area and the case-patients encompassed both adults and children. Most outbreak reports from Nepal have been from rural areas of the country involving children (23, 24). Eight (72%) of our case-patients were above the age of 5-years. Children below this age threshold are targeted by RIs and SIAs for MR vaccination. Our report highlights a changing epidemiological trend where more adults, deprived of the MR vaccine during childhood, are beginning to make up for the burden of measles-cases. An outbreak study that was done in Dhankutta, a district in the eastern region of Nepal also found more than 50% of the case patients to be above 10 years of age, all patients were fully immunized (25). Studies across Southeast Asia have similar findings where, as more children get immunized, adults represent the larger proportion of the outbreaks (26) (27). Outbreaks involving adults have been reported from factories, hostels, office complexes, detention centers, and airports (28) (12, 27, 29–31).

Previous studies of outbreaks in Nepal, mostly describing children, have pointed towards poor vaccine efficacy (23, 25). These studies have recommended improved cold chain maintenance to increase vaccine efficacy. Studies in Africa showed vaccines administered in rural regions had diminished seroconversion rates (far below 95% required for measles elimination) and low virus titers (32, 33). These findings were attributed to poor cold chain management and sub potent vaccines. Proper logistics and highly trained manpower are necessary to improve vaccine efficacy and achieve higher seroconversion rates and thus measles elimination.

Floating populations like the domestic migrant workers in our report have been attributed to disease outbreaks across the globe. They come from areas with poor access to health care and are thus likely to have not been vaccinated in their places of origin. Since vaccinations require multiple doses to ensure protection against diseases, these populations, as they move about are exempt from completing the course of their vaccination. An increase in floating populations across the world following wars and civil unrest has led to the increase in outbreaks of many communicable diseases including measles (4, 34, 35). In our report, the migrant workers came from within Nepal, from rural parts of the country where MR vaccine coverage has been poor through the years. We recommend an active search for unvaccinated individuals in the districts of origin of our case-patient and mass vaccination of such communities indiscriminate of age to prevent further outbreaks.

Our index case, who had been living in the factory for 3 months before the start of the outbreak, was likely to have acquired the virus from the community and went on to introduce the disease to a highly susceptible population. In our investigation, we could not ascertain the source of the outbreak. Every effort was made in determining the source of outbreaks since the lack of sustained transmission in an endemic region is the major criterion for establishing elimination (12).

During the outbreak duration, the Government of Nepal had enforced a country-wide lockdown to contain the COVID-19 pandemic. While the lockdown was likely to have helped contain the spread of measles in the community, it could also have prevented more patients from reaching health facilities and thus a smaller number of case-patients in our outbreak. Since measles and COVID-19 share some similar symptoms like fever and cough, some patients were unlikely to have visited health facilities due to the social stigma associated with COVID-19 in the community. Conversely, local health facilities too were less likely to have seen patients with such symptoms owing to the unavailability of personal protective equipment (36), leading to more cases being missed. During the lockdown, routine immunization services were halted, which could lead to the resurgence of cases of vaccine-preventable diseases.

The population under investigation in this report, lived in overcrowded spaces (15), which is already a risk factor for infectious disease transmission including measles. This was added upon by lockdown where the close contact between the people was
increased to 24 hours a day in the migrant labor population. The authorities need to consider such living conditions of such populations and strengthen surveillance of immunization preventable disease in such population pockets.

Several limitations should be considered, including underreporting of the symptoms. Many of the adult-case patients may have endured the disease without seeking medical care to avoid the epidemiological investigation. The enforced nation-wide lockdown may have deterred case-patients with milder symptoms from seeking medical care. The social ostracism brought on by the COVID-19 pandemic also may have led to underreporting. Interviewing of all the residents present at the beginning of the outbreak was not possible as some had returned to their villages just a few days before the lockdown began.

**Conclusion**

Urban areas are likely to have measles outbreak due to the high influx of populations migrating from areas with poor vaccination coverage. As measles vaccination coverage increases, adults who missed immunization would be the population at risk and are likely to represent a higher proportion of case-patients. Age-indiscriminate vaccination campaigns in areas with poor vaccine coverage are necessary to achieve measles-elimination status faster. Surveillance activities should focus on finding at-risk migrant labor populations who are likely to act as reservoirs or susceptible individuals for communicable diseases and immunization activities should be focused towards fully immunizing such cohorts to prevent future outbreaks. Surveillance and reporting of measles and non-measles non-rubella illnesses are cornerstones for fact-checking the status of the country in terms of proximity towards measles elimination and the work required towards that end.

**Abbreviations**

MR  
Measles Rubella  
NDHS  
Nepal Demographic Health Survey  
RI  
Routine Immunization  
SIA  
Supplementary Immunization Activity

**Declarations**

*Ethics approval and consent to participate*

This outbreak investigation was conducted as per the standard Outbreak Investigation protocol of the Ministry of Health & Population, Nepal. Ethical principles of research was followed when writing this paper and written informed consent was taken from the participants.

*Consent for publication*

Not applicable

*Availability of data and materials*

All data generated or analysed during this study are included in this published article.

*Competing interests*

The authors declare that they have no competing interests.

*Funding*

None declared.
Authors' contributions

BA conceived the idea, conducted the outbreak investigation, designed the methodology, wrote the first draft, revised subsequent draft of the paper. SSK conducted the outbreak investigation, edited the first draft, and revised the final draft of the paper. AD conducted the outbreak investigation, edited the first draft, and revised the final draft of the paper. RT reviewed and edited the paper and revised the final draft of the paper. NK reviewed and edited the paper and revised the final draft of the paper. SSB provided input on methodology, edited the first draft, revised the subsequent draft and finalized the final draft of the paper. All authors read and approved the final manuscript.

Acknowledgements:

The authors would like to acknowledge the support received from the Department of Health Services, Ministry of Health and Population, Nepal and Dr. Sagar Shakya from the World Health Organisation (WHO), Programme for Immunization Preventable Disease (IPD), WHO country Office, Nepal.

Authors' information

Affiliations

**Mulpani Primary Health Centre, Ministry of Health and Population, Kathmandu, Nepal**

Biplov Adhikari, Sauharda Singh Karki and Amrit Devkota

**B P Koirala Institute of Health Sciences, Dharan, Nepal**

Rahul Thakur

**Sahid Gangalal National Heart Centre, Kathmandu, Nepal**

Nabina Karki

**Golden Community, Lalitpur, Nepal**

Shyam Sundar Budhathoki

**Department of Primary Care and Public Health, School of Public Health, Imperial College London, London, United Kingdom**

Shyam Sundar Budhathoki

References

1. Goldani LZ. Measles outbreak in Brazil, 2018 [Internet]. Vol. 22, Brazilian Journal of Infectious Diseases. Elsevier Editora Ltda; 2018 [cited 2020 May 29]. p. 359. Available from: https://linkinghub.elsevier.com/retrieve/pii/S1413867018310420.

2. WHO

WHO. World Health Organization

WHO. Vanderende K, Gacic-Dobo M, Diallo MS, Conklin LM, Wallace AS, et al. WHO | New measles surveillance data for 2019 [Internet]. Vol. 67, WHO. World Health Organization; 2019 [cited 2020 Jun 3]. p. 1261–4. Available from: https://www.who.int/immunization/newsroom/measles-data-2019/en/.

3. World Health Organization. WHO | Measles and Rubella Surveillance Data [Internet]. Who. 2020 [cited 2020 Jun 3]. Available from: https://www.who.int/immunization/monitoring_surveillance/burden/vpd/surveillance_type/active/measles_monthlydata/en/.

4. Mipatrini D, Stefanelli P, Severoni S, Rezza G. Vaccinations in migrants and refugees: a challenge for European health systems. A systematic review of current scientific evidence. Pathog Glob Health. 2017 Feb 17;111(2):59–68.

5. Ratho RK, Mishra B, Singh T, Rao P, Kumar R. Measles outbreak in a migrant population. Indian J Pediatr. 2005;72(10):893–4.
6. Organization PAH. Measles elimination: field guide [Internet]. Scientific and Technical Publication. 2005. 97 p. Available from: http://pesquisa.bvsalud.org/bvsms/resource/pt/mis-20713.

7. Session S, Delhi N. Revising the goal for measles elimination and rubella / congenital rubella syndrome control. 2020; (September 2019).

8. WHO South-East Asia Region. sets 2023 target to eliminate measles, rubella [Internet]. [cited 2020 Jun 6]. Available from: https://www.who.int/southeastasia/news/detail/05-09-2019-accelerate-efforts-to-eliminate-cervical-cancer-who.

9. Ministry of Health Nepal. Annual Report, Department of Health Services 2074/2075. (2017/2018). Ministry of Health, Nepal; 2019. Vol. 12. 130–134 p.

10. WHO Regional Office for South-East Asia. Measles and Rubella Surveillance and Outbreak Investigation Guidelines [Internet]. 2009. Available from: https://apps.who.int/iris/bitstream/handle/10665/205481/B4314.pdf?sequence=1&isAllowed=y.

11. World Health Organisation. WHO | Response to measles outbreaks in measles mortality reduction settings. Who [Internet]. 2013; Available from:.

12. Venkat H, Briggs G, Brady S, Komatsu K, Hill C, Leung J, et al. Measles Outbreak at a Privately Operated Detention Facility: Arizona, 2016. Clin Infect Dis. 2019 Jun 1;68(12):2018–25.

13. Joshi AB, Luman ET, Nandy R, Subedi BK, Liyanage JBL, Wierzba TF. Measles deaths in Nepal: Estimating the national case-fatality ratio. Bull World Health Organ. 2009 Jun;87(6):456–65.

14. Central Bureau of Statistics - Government of Nepal NPCS. Population | Central Bureau of Statistics [Internet]. [cited 2020 May 11]. Available from: https://cbs.gov.np/population-2011/.

15. Nkosi V, Haman T, Naicker N, Mathee A. Overcrowding and health in two impoverished suburbs of Johannesburg, South Africa. BMC Public Health. 2019 Oct 24;19(1).

16. 10.1016/S0140-6736(19)30207-7
Kandel N, Lamichhane J. Female health volunteers of Nepal: the backbone of health care. Lancet [Internet]. 2019;393(10171):e19–20. Available from: http://dx.doi.org/10.1016/S0140-6736(19)30207-7.

17. Ministry of Health and Population [Nepal]. National Immunization Programme.2020, https://www.mohp.gov.np/eng/program/child-health-services/nip.

18. Khanal S, Sedai TR, Choudary GR, Giri JN, Bohara R, Pant R, et al. Progress Toward Measles Elimination — Nepal, 2007–2014. MMWR Morb Mortal Wkly Rep. 2016;65(8):206–10.

19. Introduction of Measles-Rubella Vaccine. Campaign and Routine Immunization. National Operational Guidelines; 2017.

20. Ministry of Health, Nepal

Ministry of Health, Nepal; New ERA; and ICF. 2017. Nepal Demographic and Health Survey 2016.Kathmandu, Nepal: Ministry of Health, Nepal. 2017.

21. Ministry of Health and Population (MOHP) [Nepal], New ERA, and ICF International Inc. Nepal Demographic and Health Survey 2011. Kathmandu: Ministry of Health and Population, New ERA, and ICF International, Calverton, Maryland; 2012.

22. Black FL. The role of herd immunity in control of measles. Yale J Biol Med. 1982;55(3–4):351–60.

23. Sitaula S, Awasthi GR, Thapa JB, Joshi KP, Ramaiya A. Measles outbreak among unvaccinated children in Bajura. J Nepal Med Assoc [Internet]. 2010 [cited 2020 May 7];50(4):273–6. Available from: https://pubmed.ncbi.nlm.nih.gov/22049889/.

24. Pandey Ashok D, Meghnath K, Khem P Achyut Raj GBR. Measles Outbreak in Kapilvastu, Nepal : An Outbreak Investigation Kapilvastu 2016. 2016; Available from: http://nhrc.gov.np/wp-content/uploads/2017/06/Measles-Outbreak-Investigation-1.pdf.

25. Jha N, Khan J, Prasad R, George K, Shrestha BK, Acharya B. Measles outbreak in a vaccinated population in Dhankutta. Nepal Med Coll J [Internet]. 2003 [cited 2020 May 19];5(1):16–7. Available from: https://pubmed.ncbi.nlm.nih.gov/16583967/.

26. Samaraweera B, Mahanama A, Ahamad AZ, Wimalaratne GI, Abeynayake J. The laboratory investigation of a measles outbreak in the eve of its elimination in Sri Lanka. J Clin Virol. 2020 Jan 1;122.

27. Bajaj S, Bobdey P Singh N. Measles outbreak in adults: A changing epidemiological pattern. Med J Dr DY Patil Univ. 2017;10(5):447.

28. Huang HI, Tai MC, Wu K, Bin, Chen WC, Huang ASE, Cheng WY, et al. Measles transmission at an international airport — Taiwan, March—April 2018. Int J Infect Dis. 2019 Sep 1;86:188–90.
29. Karakečili F, Akin H, Čikman A, Özćiçek F, Kalkan A. Measles outbreak in the adult age group: Evaluation of 28 cases. Mikrobiyol Bul. 2016 Jan 1;50(1):112–21.

30. 10.1186/s12879-019-4404-6
Li Z, Zhang Z, Wang F, Wei R, Zhao J, Liu F. Measles outbreak in an office building in the crowded Metropolis of Beijing, China. BMC Infect Dis [Internet]. 2019 Sep 3 [cited 2020 May 22];19(1):771. Available from: https://bmcinfectdis.biomedcentral.com/articles/10.1186/s12879-019-4404-6.

31. Ma R, Lu L, Suo L, Li X, Yang F, Zhou T, et al. An expensive adult measles outbreak and response in office buildings during the era of accelerated measles elimination, Beijing, China. Vaccine. 2017 Feb 22;35(8):1117–23.

32. Omilabu SA, Oyefolu AO, Ojo OO, Audu RA. Potency status and efficacy of measles vaccine administered in Nigeria: a case study of three EPI centres in Lagos, Nigeria. Afr J Med Med Sci [Internet]. 1999 [cited 2020 May 24];28(3–4):209–12. Available from: https://pubmed.ncbi.nlm.nih.gov/11205835/.

33. Fowotade A, Okonko IO, Nwabuisi C, Bakare RA, Fadeyi A, Adu FD. Measles vaccine potency and sero-conversion rates among infants receiving measles immunization in Ilorin, Kwara State, Nigeria. J Immunoass Immunochem. 2015 Mar;36(2)(4):195–209.

34. Williams GA, Bacci S, Shadwick R, Tillmann T, Rechel B, Noori T, et al. Measles among migrants in the European Union and the European Economic Area. Vol. 44, Scandinavian Journal of Public Health. SAGE Publications Ltd; 2016. p. 6–13.

35. Infectious Disease Implications of Large-Scale Migration of Venezuelan Nationals. - PubMed [Internet]. [cited 2020 Jun 6]. Available from: https://pubmed.ncbi.nlm.nih.gov/30192972/?from_term=measles+outbreaks+in+migrant+workers&from_exact_term=measles+outbreaks+in+migrant+workers&from_pos=2.

36. Protecting those who protect us. from the epidemic | Nepali Times [Internet]. [cited 2020 Jun 6]. Available from: https://www.nepalitimes.com/here-now/protecting-those-who-protect-us-from-the-epidemic/.

**Figures**

![First Case Identified (6 April 2020)]

**Figure 1**

Epidemic curve for the measles outbreak
Figure 2

Age and sex distribution of measles case-patients (n=11)

| Age Group              | Male | Female | Total |
|------------------------|------|--------|-------|
| 6 months to 5 years    | 9%   | 9%     | 18%   |
| 6-16 years             | 27%  | 27%    | 27%   |
| 17-24 years            | 18%  | 18%    | 36%   |
| More than 25 years     | 9%   | 9%     | 9%    |

Figure 3

Signs and symptoms of measles
