An influenza outbreak in a South African mine, following the relaxation of COVID-19 pandemic restrictions, September - December 2021

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ABSTRACT

Introduction: In November 2021, two months after lifting COVID-19 restrictions, a cluster of laboratory-confirmed influenza cases was detected outside of the normal influenza season at a mine in South Africa. We aimed to determine factors associated with influenza infection. **Methods:** A suspected influenza case was an employee presenting with acute onset of ≥1 symptom (fever, cough, rhinorrhoea, sore throat, shortness of breath, loss of smell or taste, myalgia, diarrhoea, nausea, vomiting) or any employee returning from leave or newly recruited. A confirmed influenza case was any person with laboratory-confirmed influenza. We calculated the influenza attack rate among 10 030 mine employees and assessed factors associated with influenza infection from 1 September–13 December 2021 using logistic regression. **Results:** There were 3,534 suspected influenza cases of which 161 tested influenza positive (influenza attack rate 1.6%, 161/10 030). Of the suspected influenza cases, 82% (2,886/3,534) were male and the mean age was 40-years. Among the confirmed cases, 87% (140/161) were male and the mean age was 39-years (IQR:31-45). Factors associated with laboratory-confirmed influenza were age 18-35-years (aOR 2.09; 95%CI 1.21-3.60) or 36-49 years (aOR 1.68, 95% CI: 1.02-2.79) vs. ≥50 years and working as an operator (aOR 3.47; 95%CI 1.23-9.75) or in engineering (aOR 3.20; 95%CI 1.03-9.98) vs. in the office. Of the 118 samples that were subtyped, 88 (74.6%) were influenza A(H1N1)pdm09. **Conclusion:** Out-of-season influenza outbreaks can occur in semi-closed communities. Influenza vaccines could help reduce illness and work absenteeism. Immediate recommendations included isolation of infected individuals and more personalized education to increase adherence to non-pharmaceutical interventions.

Introduction

With the emergence and spread of the novel severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) responsible for the COVID-19 pandemic, and the subsequent implementation of non-pharmaceutical interventions (NPIs) such as handwashing, wearing of face masks and social distancing, a decline in influenza cases has been observed since 2020 in South Africa and globally [1]. However, a few studies have reported unusual influenza epidemic peaks following the relaxation of social restrictions related to the COVID-19 pandemic [2, 3]. The burden of influenza in South Africa is substantial, with an estimated 10.7 million cases of influenza-like illness annually, according to a modelling study using case-based and ecological data [4]. The South African influenza season is usually between May and September [5, 6], but no influenza season was observed in 2020 and 2021. However, according to the Centre for Respiratory Diseases and Meningitis (CRDM) at the South Africa National Institute for Communicable Diseases (NICD), there was an increase in influenza cases from 24 August 2021 which peaked in week 46 (14-20 November 2021) and decreased until week 51 (19-25 December 2021) [7-9]. During this period, most restrictions related to the control of the COVID-19 pandemic had been relaxed. In March 2020, South Africa announced a national lockdown to try and curb the spread of COVID-19. Lockdown restrictions were lifted in a phased approach, starting from Level 5 (travel between provinces, metropolitan areas, and districts prohibited, unless proven essential), implemented on 27 March 2020, to Level 1, a relaxation of most restrictions, implemented on 4 October 2021. South Africa moved from adjusted alert level 3 (26 July 2021 - 12 September 2021), to adjusted alert level 2 (13-30 September 2021), a relaxation in restrictions allowing for spectators at events (such as sporting events) and lifting of curfews that limited the movement of people [10-12].

A private laboratory notified CRDM on 10 November 2021 of an increase in the number of influenza A cases in the Waterberg district in Limpopo Province. Of note was an increase in the number of influenza A cases at a mine in the province, which prompted further investigation.

Due to the high number of cases, the possible disruption of work, and the unique opportunity to describe influenza cases after almost two years of limited influenza activity in South Africa, teams from the NICD, National Department of Health (NDoH), Limpopo Department of Health (LDoH) (both district and provincial departments) and World Health Organization (WHO) were jointly deployed to the mine on 22 November 2021 to investigate and respond to the possible outbreak.

The aim of this study was to confirm the existence of an influenza outbreak, identify circulating strains, and determine factors associated with influenza infection at the mine in South Africa. Additionally, this outbreak investigation aimed to provide recommendations to the mine to limit transmission during the outbreak and support ongoing testing to mitigate future outbreaks and large disruptions to the workforce.

Methods

Study Setting and Population

This study was conducted at a platinum mine in the Thabazimbi Municipality of the Waterberg district within the Limpopo Province of South Africa. Limpopo is one of nine South African provinces with an estimated population of 5.4 million [13] . The province has the highest ground resources (such as coal and platinum), and mining is the largest contributor to its Gross Domestic Product (57.5%). The Waterberg district houses 40% of the coal reserves in the country and also hosts iron ore and platinum mines [14].

The platinum mine has mixed mining operations, including deep underground shafts and open shafts above ground. It is situated in a peri-urban area and is considered a semi-closed community, as a variety of services are offered on-site, including health services, accommodation for mine employees, and shopping centres. At the time of investigation, the mine had 10 030 employees.

Employees who do not stay on the mine premises, occupy formal and informal housing in the surrounding areas. There are eight work areas on the mine, including office buildings and mine shafts (Table 1), which have been anonymised to protect confidentiality. In total, 814 employees reside in three types of housing provided, which include hostels, mine houses, or apartments. Permanent

employees and their dependents receive healthcare services through a private healthcare provider, which has facilities at the mine and surrounding areas. This private healthcare provider has one hospital on the mine premises. This hospital sees a daily average of 150-200 outpatients, and 5-20 casualty patients and has an admission capacity of 41 beds. A Public healthcare clinic is situated at the mine and caters to mine employees and residents from the surrounding areas. The healthcare clinic sees an average of 60-70 outpatients per day. The hospital is only used by those who have private healthcare and can accommodate hospital admissions. The clinic does not accommodate for admissions and serves anyone in the private or public sector. Contract employees use their own health insurance and can seek care at any of the private or public facilities in the area, including the facilities located at the mine.

Case definition and testing strategy

We defined a suspected case of influenza as an employee who presented with acute onset of any one of the following symptoms (fever, cough, runny sore throat, shortness of breath, loss of smell or taste, myalgia, diarrhoea, nausea and vomiting) or any employee returning from leave or a newly recruited employee. A confirmed influenza case was defined as any person with laboratory confirmed influenza, with or without signs and symptoms. If the new recruits did not show any symptoms, they were allowed to start working until they had their test results. The reason for testing (i.e. being symptomatic, returning from leave or being a new recruit) was not available in the data provided. From 1 June 2021, specimens were tested for SARS-CoV-2 by using a multiplex PCR assay that simultaneously detected influenza A, influenza B and respiratory syncytial virus (RSV). These additional pathogens were added to the mine´s testing routine due to the availability of this multiplex assay at the same cost as previous SARS-CoV-2 PCR tests.

Specimen collection and laboratory testing

Nasopharyngeal swabs were collected and transported to a private laboratory for testing as dry swabs (according to the laboratory´s Standard Operating Procedure). The mine had an agreement with the private laboratory to test specimens, with quality assurance and control procedures in place. Upon their reciept at the laboratory, the swabs were re-suspended in 2mL saline prior to extraction and tested for influenza A and B viruses, RSV, and SARS-CoV-2 using a commercial multiplex real-time PCR (RT-PCR) assay, according to the manufacturer instructions (Allpex SARS-CoV-2/FluA/FluB/RSV PCR kit, Seegene Inc., Seoul, South Korea). Influenza A and B positive specimens were subtyped at the NICD using the United States Centers for Disease Control and Prevention (CDC) RT-PCR protocol and reagents [15].

Data analysis

The influenza attack rate was calculated by dividing the total number of employees testing positive for influenza by the total number of individuals working at the mine. If employees were tested multiple times, only the positive test was used. The last testing date was used if the multiple tests were all negative. None of the employees tested more than once had more than one positive test in our study frame. To assess the factors associated with influenza infection, we performed logistic regression investigating age, sex, area of work, and occupation. We first evaluated all variables on univariate analysis and evaluated any characteristics with p-values <0.2 in the multivariable analysis. A manual backward step-wise selection was used, retaining only variables with p-values <0.05 in the final model. The data was analysed using Stata (version 16, Stata Corp LLC, College Station, TX, United States of America, 2019).

Ethical considerations

To prevent leaking of personal information, we kept password-protected files on a password-protected laptop. Outbreak response investigation activities of the NICD was granted ethical clearance from the Human Research Ethics Committee (Medical) of the University of the Witwatersrand, reference M210752. Additional ethical clearance was granted by the Limpopo Department of Health, reference LP_2023_01_015.

Results

Characteristics of mine employees

The mean age was 40 years. Additionally, there were more male (8 353/10 030, 83.2%) employees than female employees. Areas 7 and 8 had the most employees (2 751/10 030, 27.4%, and 3 621/10 030, 36.1%, respectively). Employees working in underground mining (2 043/10 030, 20.5%) and operators (2 035/10 030, 20.3%), were the most prevalent occupation categories (Table 2). Those working in engineering had a median age of 36 years (IQR: 29-41) and 82.3% (415/504) were male. Those working as operators had a median age of 41 (IQR:35-48),) and 96.2% (1 958/2 035) were male.

Of the 10 030 employees, 4 516 specimens were collected and tested for SARS-CoV-2, influenza A and B, and respiratory syncytial virus (RSV) from 1 September to 13 December 2021. Of these, 982 individuals who were tested more than once and those with multiple negative tests were excluded from analysis. The total number of suspected influenza cases were 3,534, out of which 161 (4.6%) were confirmed influenza A cases between 1 September and 13 December 2021 (Table 2). Amongst all employees, the overall influenza A attack rate was 1.6% (161/10 030). No influenza B was detected. Considering the distribution of the cases over time, 6 of the 161 (3.8%) positive individuals were detected in September, 47/161 (29.1%) individuals in October, 96/161 (59.6%) in November, and 12/161 (7.5%) in December (Figure 1). The highest number of cases was seen on 8 November, with 15/161 (9.3%) positives identified (Figure 1). No individuals presented with severe disease.

Subtyping was carried out on 118 specimens, of which influenza A(H1N1)pdm09 was predominant (88/118, 74.6%), followed by influenza A(H3N2) (14.4%, 17/118)- no specimens were subtyped in December. (Figure 2). Subtype could not be confirmed for 11 samples due to low viral load (Cycle threshold > 35). One influenza A(H1N1) pdm09 and SARS-CoV-2 co-infection and one influenza A(H3N2) and SARS-CoV-2 co-infection were detected.

Factors associated with testing positive for influenza

Among those with an influenza infection, 51% (82/161) were in the 36-49 years age group and 87% (140/161) were male. Additionally, 25% (41/161) worked in underground mining, and 34% (55/161) worked as machinery operators. On multivariable analysis, factors associated with laboratory-confirmed influenza infection were being aged 18-35 years (Adjusted odds ratio (aOR) 2.09, 95% confidence interval (CI): 1.21-3.60) or 36-49 years (aOR 1.68, 95% CI: 1.02-2.79) compared to those aged ≥50 years. Compared to office workers, those working as operators (aOR 3.47, 95% CI: 1.23-9.75) or in engineering (aOR 3.20, 95% CI: 1.03-9.98) had statistically significantly higher odds of being infected. Additionally, those who had a permanent position had statistically significantly higher odds of being infected (aOR 1.52, 95% CI: 1.06-2.16) compared to contract workers (Table 3).

During the visit to the accommodation village, all COVID-19 prevention measures were in place. These measures included mask mandates, sanitation stations at all entrances and limited occupants in dining halls during meals.

Discussion

In this study, we investigated and confirmed the existence of an influenza A outbreak that occurred in a mine where 161 influenza A positive cases were reported between 1 September and 13 December 2021, with an overall attack rate of 1.6%. A clear increase in cases was observed from October, peaking in November and declining in December, which is outside of the normal influenza season in South Africa. This outbreak was predominantly driven by the influenza A(H1N1)pdm09 subtype. This differs from other semi-closed community influenza outbreaks that were mostly driven by the influenza A(H3N2) subtype [2, 3, 16] .

This outbreak was detected when the South African government relaxed COVID-19 prevention restrictions. There was also a general increase in influenza cases in the country around the same time, which could be attributed to the lifted control measures at the time. Prolonged restrictions could lead to an immunity gap (defined as the increased

proportion of the population who do not have protective level of antibodies to influenza infection following the relaxation of COVID-19 restrictions) in the population and rendering them more susceptible when control measures were lifted [17]. A decline in influenza cases was also seen in other countries in both the Northern and Southern Hemispheres, such as the United States of America, Chile and Paraguay [1, 18]. This immunity gap may have led to the increase in influenza cases during the spring and summer months when historically low influenza circulation has been seen [6].

The absence of a typical influenza season during the winters of 2020 and 2021 in South Africa and the low influenza vaccination coverage in the province [20] could have contributed to an immunity gap in the community. Prior to the COVID-19 pandemic, South Africa hosted annual influenza vaccination campaigns in the public sector. In 2021, no influenza vaccination campaign was hosted due to financial constraints, and South Africa distributed 871, 910 influenza vaccines nationally in the public sector, and 612, 848 (70.3%) were used [20]. No influenza vaccines were utilised in Limpopo Province in the public sector [20]. Similarly, the mine also hosted annual influenza vaccination campaigns in the years prior to the COVID-19 pandemic. No influenza vaccination campaign has been implemented at the mine since the start of the pandemic to prioritize COVID-19 vaccination. However, influenza vaccines were still available at the local hospitals for those with medical insurance. This immunity gap caused by low vaccination uptake could be a possible explanation for the increase in influenza infections out of the normal season and emphasises the need to continue vaccination programs for commonly circulating pathogens during an era of novel epidemics and outbreaks.

One reason this outbreak was detected was because of routine COVID-19 screening. Including influenza and RSV in a multiplex assay allowed for detection of an increase in influenza cases, which might have been otherwise missed by routine surveillance. Multiplex pathogen assays are helpful in detecting multiple pathogens using a single test, with a single specimen. Using multiplex PCR assays in diagnostics and surveillance can improve respiratory pathogen detection [20]. Such approaches are useful for differential diagnosis and should be considered in surveillance and routine testing where resources for early detection, reporting and response to potential outbreaks are available.

Factors associated with influenza infection identified in this study were individuals aged 18-49 years, individuals who worked as operators or as engineering workers, and permanent workers. Compared to people over the age of 50 years, those aged 18-35 years had the highest adjusted odds of influenza infection followed by those who were aged 36-49 years. Although previous studies have shown higher risk of moderate to severe illness (outpatient or hospitalised) individuals [21], in this study, the increase in odds of infection was in the younger age groups compared to those in 50+ years age group. While this could be due to behaviour and contact patterns, we did not investigate this further.

Permanent workers were more likely to be infected than contract workers in this study. While we did not come across this finding in other studies, we postulate that contract workers are less likely to disclose their symptoms for fear of not being paid as their contracts are generally on “no-work-no-pay” basis. Permanent workers, on the other hand, have designated sick leave days and are more likely to disclose when they feel ill and subsequently get tested, resulting in higher odds of having laboratory-confirmed influenza infection identified. We speculate further that contract workers had lower odds of infection due to reluctance of being unable to work considering that the unemployment rate in South Africa during the third quarter of 2021 was 34.9% [22]. An alternative explanation could be that the contract workers sought healthcare outside of the mine facilities and were therefore not detected in this study.

Those who worked as operators or engineers were also associated with increased odds of influenza infection, possibly because these professions require contact regularly with other workers in multiple departments when operating machinery or repairing equipment. Such employees are also more likely to work underground in the mining shafts where there is low ventilation which could contribute to the risk of transmission of respiratory pathogens [23]. According to our literature search, there is only one influenza mine outbreak in South Africa, and none in the rest of the world at the time of reporting this study.

The subtyping results indicated circulation of both influenza A(H1N1)pdm09 and influenza A(H3N2). These strains were likely introduced from surrounding communities [8], staff that returned from leave or new staff entering the mine. In the neighbouring provinces of Gauteng and North West, influenza A(H1N1)pdm09, influenza A(H3N2), and influenza B/Victoria were reported to be circulating as detected through the influenza-like illness and Viral Watch surveillance programmes [7]. In addition, healthcare facilities outside of the mine verbally reported a higher number of respiratory illness-related consultations, and of these consultations, most patients tested negative for COVID-19, suggesting another respiratory pathogen (such as influenza) circulating in the community.

No hospital admissions resulted from the cases detected among the employees of the mine, and thus there was no concern regarding increased influenza disease severity following two years of limited influenza circulation. This outbreak suggests individual non-compliance to non-pharmaceutical interventions (NPI´s) that were in place to reduce SARS-CoV-2 transmission, such as wearing of masks, physical distancing, regular washing, or sanitization of hands.

Recommendations to reduce the spread of influenza in the workforce were specifically tailored for South Africa [6], and aligned with international guidelines set by the WHO [24]. These included staying at home until symptoms have resolved, social distancing, regular washing of hands, covering of coughs and sneezes, and prioritising vaccination among those at risk for severe disease such as the elderly (≥65 years old), pregnant and post-partum women, people living with HIV, people with tuberculosis, people with chronic diseases (diabetes, asthma, heart, kidney or liver disease) and persons who are morbidly obese (i.e. body mass-index ≥40). Furthermore, education on influenza transmission and health promotion was encouraged.

Limitations of this study included possible missed positive cases where employees did not disclose symptoms or were asymptomatic and contributed to influenza transmission [21]. Additionally, symptomatic employees could also not be tested due to absenteeism, even when they had symptoms. Thus, there might be an underestimation of the true number of infected employees in the study period. Since the reason for testing (i.e. being symptomatic, returning from leave or being a new recruit) was not available in the data provided, we were not able to assess for their association with testing positive.

Even though global influenza circulation was low during the first two years of the COVID-19 pandemic [25], this outbreak serves as an important reminder that influenza was still circulating during that period. Despite lower influenza transmission during the COVID-19 pandemic, this study illustrates why surveillance and public health priorities should not shift completely to novel pathogens that cause pandemics, such as SARS-CoV-2, but rather routine monitoring of common respiratory pathogens should still be conducted within the wider context of surveillance and control of novel pathogens with pandemic potential. Furthermore, routine surveillance can be strengthened with additional sentinel sites, especially in under monitored and rural areas.

Conclusion

We confirmed an influenza outbreak, driven by influenza A(H1N1)pdm09 in a mine in Limpopo Province, South Africa. As shown in this study, influenza outbreaks in mines can occur occasionally outside of normal influenza seasons. Our immediate recommendations, included isolation of infected individuals and individual-level education to increase adherence to non-pharmaceutical interventions. This study highlights that outbreaks of common respiratory viruses can occur within the context of COVID-19 and similar novel pandemics, and emphasises the need for vaccinations campaigns to decrease morbidity and work absenteeism due to influenza illness. Additionally, this showcases the importance of maintaining routine surveillance, even during pandemics.

What is known about this topic

- Unusual influenza epidemic peaks following the relaxation of social restrictions related to the COVID-19 pandemic
- Influenza outbreaks may occur in semi-closed communities

What this study adds

- Influenza A(H1N1)pdm09 and influenza A(H3N2) circulated in this community after 2 years of limited influenza circulation, likely due to the COVID-19 pandemic
- Younger individuals aged 18-49 years had higher odds of being infected with influenza compared to those above 50 years old. The odds of being infected were higher among the 18-35 year age group compared to the 36-49 year age group
- Those working in enclosed areas had higher odds of being infected with influenza
- Importance of maintaining routine surveillance even during epidemics

Competing interests

CC has received grant support from Sanofi, Pasteur, US CDC, Welcome Trust, Programme for Applied Technologies in Health (PATH), Bill & Melinda Gates Foundation and South African Medical Research Council (SA-MRC). NW has received grant funding from Sanofi and the Bill and Melinda Gates Foundation.

Authors' contributions

FE: investigation, data analysis, writing original draft, review and editing; MK: investigation, review and editing; IK: investigation, review and editing; HM: review and editing; SW: review and editing, conception of the study; CC: review and editing, conception of the study; AvG: review and editing, conception of the study; FM: laboratory analysis and review; CNU: laboratory analysis, review and editing; ZM: review and editing; GN: Initial planning, reviewing data collection tools (case investigation form), review and editing; AMS: Initial planning, reviewing data collection tools (case investigation form), review and editing; NG: Initial planning, review and editing; HT: laboratory analysis, review and editing; LD: laboratory analysis, review and editing; CM: investigation, review and editing; MFN: investigation, review and editing; JK: conceptualisation, investigation, data analysis, writing original draft, review and editing. All authors consented to the manuscript being submitted for publication.

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Tables and figures

Table 1: Major business units in the mine, with their function and number of employees

Table 2: Characteristics of the employees and those tested for influenza in a mine in Limpopo Province, South Africa, during 1 September to 13 December 2021 (N=3,534)

Table 3: Factors associated with influenza infection in a mine in Limpopo Province, South Africa, during 1 September to 13 December 2021

Figure 1: Laboratory-confirmed influenza A cases from 1 September to 13 December 2021, in a mine in Limpopo Province, South Africa

Figure 2: Circulating influenza subtypes identified in a mining community, Limpopo Province, South Africa, 1 September –13 December 2021, N=118

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Table 1: Major business units in the mine, with their function and number of employees		
Major business unit	**Function**	**Number of employees**
Area 1	Underground mining	1,196
Area 2	Administrative	120
Area 3	Administrative	1,283
Area 4	Processing raw materials	752
Area 5	Processing raw materials	224
Area 6	Open cast mining	83
Area 7	Underground mining	2,751
Area 8	Underground mining	3,621
Total		10,030
*Area 1- underground mining, Area 2- administrative building, Area 3- administrative building, Area 4- area for processing raw materials, Area 5- area for processing raw materials, Area 6- open cast mining, Area 7- underground mining, Area 8- underground mining [#]This excludes 982 employees who were tested more than once and those with multiple negative tests.		

Table 2: Characteristics of the employees and those tested for influenza in a mine in Limpopo Province

Characteristic	**Employees n (%) N=10,030**	**Employees that Tested for influenza N=3,534[#]**	
		Negative n (%) n= 3,373	**Positive n (%) n= 161**
Age group (years)			
18-35	3,449 (34)	1,166 (35)	60 (37)
36-49	4,757 (47)	1,629 (48)	82 (51)
50+	1,824 (18)	578 (17)	19 (12)
Sex			
Female	1,677 (17)	627 (19)	21 (13)
Male	8,353 (83)	2,746 (81)	140 (87)
Nationality			
Botswana	2 (0)	1 (0)	0 (0)
Lesotho	153 (2)	30 (1)	1 (1)
Malawian	2 (0)	0 (0)	0 (0)
Mozambique	461 (5)	56 (2)	2 (1)
South African	9,346 (93)	3,271 (97)	158 (98)
Swazi	31 (0)	10 (0)	0 (0)
Zambian	1 (0)	1 (0)	0 (0)
Zimbabwean	34 (0)	4 (0)	0 (0)
Type of worker			
Contract	4,472 (45)	1,311 (39)	55 (34)
Permanent	5,558 (55)	2,062 (61)	106 (66)
Area of work*			
1	1,196 (12)	417 (12)	21 (13)
2	120 (1)	53 (2)	0 (0)
3	1,283 (13)	446 (13)	9 (6)
4	752 (7)	265 (8)	7 (4)
5	224 (2)	66 (2)	4 (2)
6	83 (1)	12 (0)	1 (1)
7	2,751 (27)	917 (27)	57 (35)
8	3,621 (36)	1,197 (35)	62 (39)
Occupation			
Health and Safety	388 (4)	148 (4)	2 (1)
Engineering	504 (5)	190 (6)	13 (8)
Underground mining	2,043 (20)	687 (20)	41 (25)
Maintenance	464 (5)	164 (5)	7 (4)
Operators	2,035 (20)	656 (19)	55 (34)
Drivers	642 (6)	235 (7)	12 (7)
Supervisors	831 (8)	261 (8)	17 (11)
Office	589 (6)	205 (6)	4 (2)
Other	2,534 (25)	827 (25)	10 (6)

*Area 1- underground mining, Area 2- administrative building, Area 3- administrative building, Area 4- area for processing raw materials, Area 5- area for processing raw materials, Area 6- open cast mining, Area 7- underground mining, Area 8- underground mining

[#]This excludes 982 employees who were tested more than once and those with multiple negative tests

Table 3: Factors associated with influenza infection in a mine in Limpopo Province, South Africa, during 1 September to 13 December 2021

		Univariate analysis		Multivariable analysis	
Characteristic	**Influenza N=161**	**Crude OR (95% CI)**	**p-value**	**Adjusted OR (95% CI)**	**p-value**
Age group (years)					
18-35	60(37)	1.68 (1.00-2.83)	0.050	2.09 (1.21-3.60)	0.008
36-49	82(51)	1.67 (1.01-2.75)	0.046	1.68 (1.02-2.79)	0.043
50+	19(12)	Reference		Reference	
Sex					
Female	21(13)	Reference			
Male	140(87)	1.34 (0.85-2.13)	0.209		
Nationality					
Botswana	0(0)	Not determined			
Lesotho	1(1)	0.38 (0.05-2.75)	0.340		
Malawian	0(0)	Not determined			
Mozambique	2(1)	0.25 (0.06-1.03)	0.055		
South African	158(98)	Reference			
Swazi	0(0)	Not determined			
Zambian	0(0)	Not determined			
Zimbabwean	0(0)	Not determined			
Ethnicity					
African	159(99)	3.02 (0.75-12.25)	0.121		
Asian	0(0)	Not determined			
Coloured	0(0)	Not determined			
White	2(1)	Reference			
Type of worker					
Contract	55(34)	Reference		Reference	
Permanent	106(66)	1.56 (1.12-2.17)	0.008	1.52 (1.06-2.16)	0.021
Area of work*					
1	21(13)	2.53 (1.15-5.55)	0.020		
2	0(0)	Not determined			
3	9(6)	Reference			
4	7(4)	1.33 (0.49-3.59)	0.573		
5	4(2)	2.57 (0.79-8.43)	0.118		
6	1(1)	1.73 (0.22-13.79)	0.607		
7	57(35)	3.00 (1.48-6.07)	0.002		
8	62(39)	2.47 (1.22-4.98)	0.012		
Occupation					
Health and Safety	2(1)	0.76 (0.14-4.16)	0.749	0.69 (0.13-3.81)	0.673
Engineering	13(8)	3.87 (1.25-11.95)	0.019	3.20 (1.03-9.98)	0.045
Underground mining	41(25)	3.00 (1.07-8.40)	0.037	2.65 (0.94-7.46)	0.066
Maintenance	7(4)	2.24 (0.65-7.70)	0.200	2.03 (0.59-7.02)	0.262
Operators	55(34)	4.06 (1.47-11.26)	0.007	3.47 (1.23-9.75)	0.019
Drivers	12(7)	2.79 (0.89-8.69)	0.077	2.32 (0.73-7.36)	0.153
Supervisors	17(11)	3.05 (1.02-9.12)	0.046	2.93 (0.96-8.90)	0.058
Office	4(2)	Reference		Reference	
Other	10(6)	0.58 (0.18-1.85)	0.358	0.51 (0.16-1.65)	0.263

*Area 1- underground mining, Area 2- administrative building, Area 3- administrative building, Area 4- area for processing raw materials, Area 5- area for processing raw materials, Area 6- open cast mining, Area 7- underground mining, Area 8- underground mining

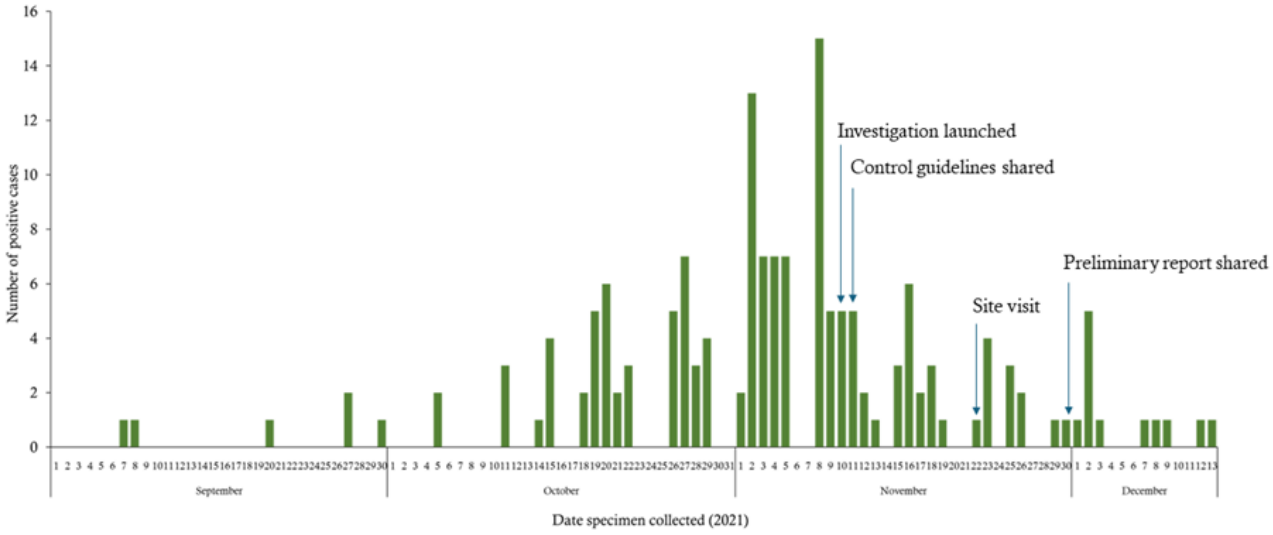

Figure 1: Laboratory-confirmed influenza A cases from 1 September to 13 December 2021, in a mine in Limpopo Province, South Africa

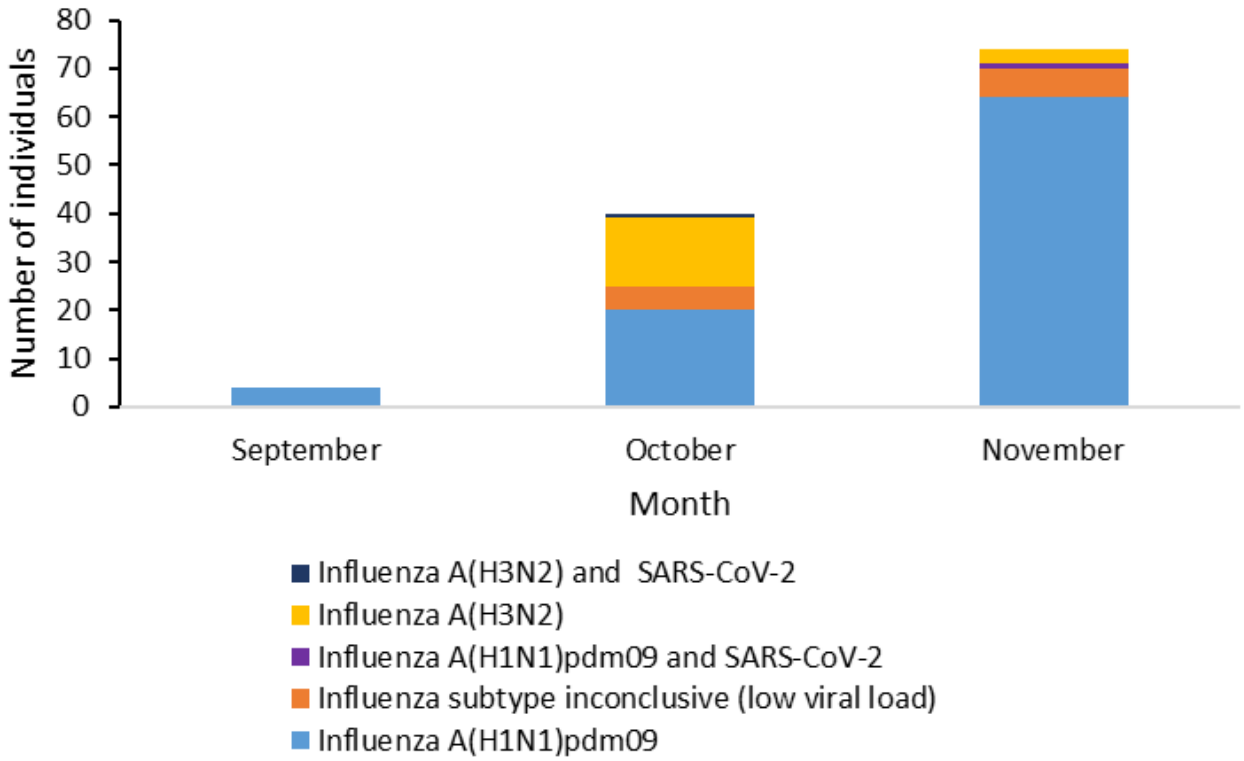

Figure 2: Circulating influenza subtypes identified in a mining community, Limpopo Province, South Africa, 1 September – 13 December 2021, N=118