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CASE STUDY

# Maintaining production levels in underground mining operations during pandemics - a case study

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## Abstract

The outbreak of pandemics has dire consequences on businesses, industries and economies. The resulting ill-health and natural panic of the workforce tend to impact production levels, yet serious businesses such as mining ventures, must strive to make profit. To achieve objectives, businesses must put in measures to remain afloat. In this study, measures implemented by Chirano Gold Mines Limited (CGML) during Covid-19 were examined. Secondary production data spanning from 2019 to 2021 was used to appraise the performance of the mine in maintaining production levels in underground operations during the surge of the pandemic by using field visits and the administration of questionnaires. The data analysis showed that in 2020, 98.23 % and 72.72 % of the target for production and development, respectively, were met; also, 72.95 % and 92.61 % of the blasting target and ore tonnes mined were achieved respectively. Among the three years, 2020 had the highest ore production tonnage, with June recording the least value and October recording the highest value. The study found that education, effective communication of Covid-19 protocols, and the use of working shift manoeuvres were key in achieving the targets.

**Keywords**: Maintaining Production Levels, Covid-19, Development Drilling, Blasted Ore Tonnes, Underground Mining Operations, Pandemics

## Introduction

The outbreak of pandemics can have far-reaching and severe consequences on various aspects of society, including businesses, industries, and economies. The disruptions caused by pandemics can lead to significant economic losses, reduced production levels, and sometimes business closures (Kolomak, 2020). These consequences are not only limited to a specific industry or region but can have a global effect. During pandemics, businesses may face significant challenges, including supply chain disruptions, reduced demand for goods and services, workforce shortages and even household economies (Berry *et al*., 2020; Celik and Dane, 2020; Kolomak, 2020; Shang *et al*., 2021). These challenges can cause delays or reduction in production, shortages in essential supplies, and, ultimately, financial losses. According to Candra and Rekha (2020), the tourism and hospitality industries are especially vulnerable to pandemics due to travel restrictions and social distancing measures implemented to curb the spread of the disease.

The disruption of businesses and industries can lead to high levels of unemployment, reduced consumer spending, and reduced government tax revenues, which may cause economic downturns, recessions, and even depression (Shang *et al*., 2021). Also, pandemics can result in the loss of human lives, which is irreparable (Debata et al., 2020; Trzebiński et al., 2020). Furthermore, the social and psychological effects of pandemics, such as fear and anxiety, can also have long-lasting consequences (Debata *et al*., 2020; Qiu *et al*., 2017; Shah *et al*., 2022; Trzebiński *et al*., 2020).

The coronavirus 2019 (Covid-19) is a disease caused by a group of viruses that lead to respiratory tract infections ranging from mild to lethal. On March 11, 2020, the World Health Organisation (WHO) declared Covid-19 a global pandemic (Rampal and Seng, 2020). Eventually, Ghana confirmed its first case on March 12, 2020, resulting in a national lockdown on March 30, 2020. The coronavirus 2019 can wipe out people's lives, businesses, industries, and economies, which can potentially have severe short-term, medium-term, and long-term ramifications for industries as a whole (Laing, 2020).

Ghana is endowed with a vibrant gold mining industry that contributes immensely to the country's economy. In 2018, Ghana became Africa's largest gold producer and ranked eighth in the world. In 2020, there was a decline in gold production from both large and small-scale producers; the large-scale sector declined by 6 %, while the small scale declined by 20.4 %. Overall, Ghana's total gold output for 2020 fell by 11 % (Ahadjie et al., 2021). The declines were possibly attributable to the Covid-19 pandemic. However, gold mining companies in Ghana were exempted from the lockdown and so could continue their operations. Although a small number of Covid-19 cases were reported at some of the mines, only one mine suffered a decrease in production because some of its workers had to undergo quarantine (Asante-Poku and van Huellen, 2021). Gold, unlike other minerals, acted differently as gold price rose during the crisis. In general, the gold mining industry was the backbone of the mineral resource industry in Ghana during the pandemic surge. In fact, gold production accounted for 97 % of the country's total mineral exports in 2020 (Ahadjie *et al*., 2021).

Chirano Gold Mines Limited (CGML), a former subsidiary of Kinross Gold Corporation and currently a subsidiary of Asante Gold Corporation, is used as the case study in this research. CGML operates underground and open pit mines in the Western North Region of Ghana. Presently, the mine operates three open pits and six underground mines. According to the 2020 Kinross Gold Annual Report, by the end of 2020, tonnes of ore mined at Chirano Gold Mines Limited had increased by 19 % compared to the previous year (Anon, 2021). This result was partially attributed to more tonnes of ore mined in 2020 than in 2019 despite the pandemic.

This study focused solely on the underground department of the mine. The research analysed the impacts the pandemic

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surge had on the underground production operations of the mine and also evaluated the enigmas of the outstanding performance of the company despite the pandemic surge.

## Materials and Methods

### Study area description

CGML is a mining company situated in the southwestern part of Ghana in the Bibiani-Anhwiaso-Bekwai Municipal District in the Western North Region of Ghana (Figure 1). The deposits occur at regular intervals along a ten km-long mineralised zone called the Chirano Lode Horizon. Oppong and Agyei (2020) stated that in the CGML concession, gold reserves are found in broken and altered mafic volcanic rocks and granite intrusives that comprise multiple tiers of parallel mineralised cataclasites, veinlet stockworks, and veinlets that are stacked on top of each other. Gold mineralisation of the Chirano deposits is associated with ankerite, sericite, albite, silica, hematite and pyrite assemblage (Ackun-Wood *et al*., 2016). The mine area is characterised by the wet semi-equatorial climate, which is characterised by two rainfall maxima of May-July and September-October with a mean annual rainfall of 1500 mm and a mean monthly temperature of 26 °C to 30 °C (Baaku, 2013). It is established that the area falls within the physiographic region of a forest-dissected plateau characterised by a reasonably undulating relief. Chirano Gold Mines Limited uses a highly mechanised mining method.

### Dataset acquisition and description

The data used are secondary, together with some other information that was gathered through interactions with the Medical Doctor in charge of the Mne Clinic, the Operations Engineer of the Underground Operations Department and the Mine Planning Engineer. The acquired data consisted of six different sets. Five sets of data comprised total yearly records from 2019 to 2021. These data included two sets of drilling data, two sets of blasting data, and the annual hauled ore material data. The remaining dataset comprised the monthly records of the hauled ore production tonnage for the Covid-19 surge year 2020. The data collected was a record combination of the six underground workings in CGML.

#### *Production and development drilling data*

The drilling data was explicitly made up of production drill metres (PDM) and development drill metres (DDM) from the year 2019 to the year 2021. This data set contained the estimated and actual drill metres for both production drill metres and development drill metres to establish a trend of the drilling data to draw an inferential conclusion. The production drill metres are hole lengths drilled to target for the production of the ore. In situations where drilling was done inaccurately, secondary drilling was done to achieve an accurate drill plan. These re-drilled hole lengths are inclusive and considered production drill metres. The development drill metres refer to hole lengths drilled to advance the face of the mine. Table 1 shows a summary of PDM and DDM in metres.

#### *Blasting and ore production tonnage data*

The blasting data contained data on production blasted tonnes and total ore tonnes. The actual and estimated production blasted tonnes and the total ore tonnes were collected. In CGML, the actual production blasted tonnes (PBT) refers to the real tonnage of the ore material in the stope that was blasted. In contrast, the estimated production of blasted tonnes refers to the designed tonnage of the ore in the stope given by the geologist. On the other hand, the total ore tonnes (TOT) refers to the total amount of ore obtained from production, development and any

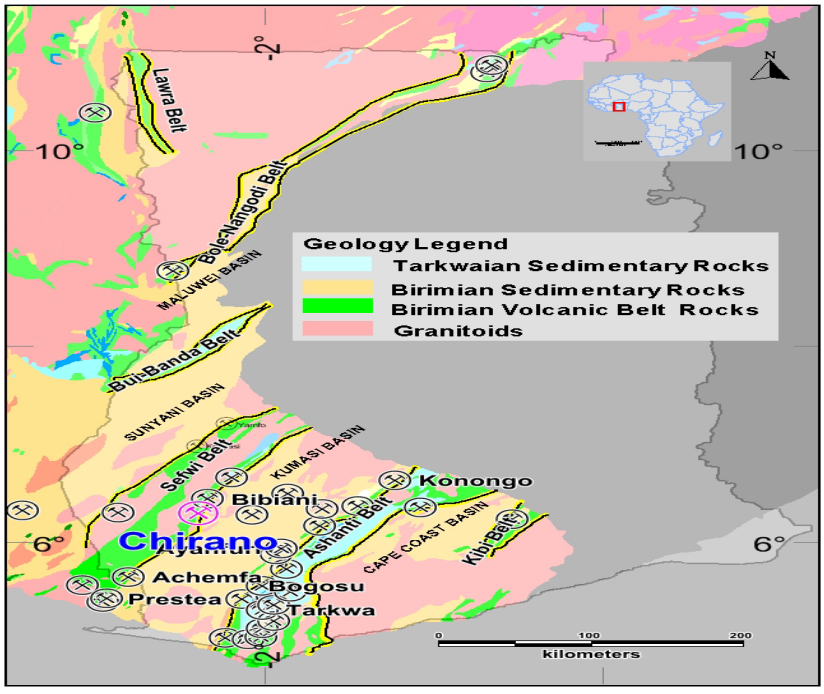



**Figure 1** Regional geological map of Ghana (Source: Ackun-Wood *et al*., 2016)

**Table 1** Summary of production and development drilling data in metres

| Year | Actual PDM (m) | Estimated PDM (m) | Actual DDM (m) | Estimated DDM (m) |
|---|---|---|---|---|
| 2019 | 130,548.60 | 196,641.51 | 9,505.04 | 9,031.47 |
| 2020 | 183,914.64 | 187,230.90 | 7,941.94 | 10,922.00 |
| 2021 | 229,833.10 | 201,118.62 | 10,554.48 | 10,461.00 |

further excavation made in the mine. A summary of the blasting data acquired is presented in Table 2. Ore production tonnage refers to the total amount of material hauled out of the mine where the ore and waste are included. Figure 2 shows the respective monthly performance for the Year 2020.

## Results and Discussion

### Results and analyses

From the data collected, results were obtained in a manner where the actual data was measured against the estimated data for each set by comparing the actual percent to the estimated percentage of each data set. The estimated percent for each data set was 100 %. This depicted the distinct trend of each data set. This section may be divided by subheadings.

#### *Production drill metres results and analysis*

The actual production drill metres in 2019 were 66.39 % of the estimated production drill metres (Table 1). CGML had a shortage of 66,092.91 m (33.61 % of the estimated production metres) and did not meet the target production drill metres. In 2020, the actual production drill metres was 98.23 % of the estimated production drill metres. CGML had a shortage of 3,316.26 m production drill metres, approximately 1.77 % of the estimated production drill metres. In 2021, the target was exceeded by 28,714.48 m. Hence, an extra 14.28 % of the set target was achieved to give the actual production drill metres that year. Figure 3 presents the production drill metres data from 2019 to 2021.

#### *Development drill metres results and analysis*

In 2019, the estimated development drill metres exceeded by an additional 5.25 % of the estimated drill metres, as seen in Table 1. In 2020 however, only 72.72 % of the estimated development drill metres was achieved. In 2021, the estimated development drill metres exceeded by 0.89 %. Figure 4 shows a graph of the development drill metres from 2019 to 2021.

**Table 2** Summary of blasting data in tonnes (t)

| Year | Actual PBT | Estimated PBT | Actual TOT | Estimated TOT |
|---|---|---|---|---|
| 2019 | 88,108.90 | 1,306,569.21 | 1,972,215.16 | 1,856,463.80 |
| 2020 | 1,171,144.26 | 1,605,491.96 | 2,010,288.89 | 2,170,656.78 |
| 2021 | 1,273,652.17 | 1,503,738.49 | 1,900,484.85 | 2,140,778.44 |

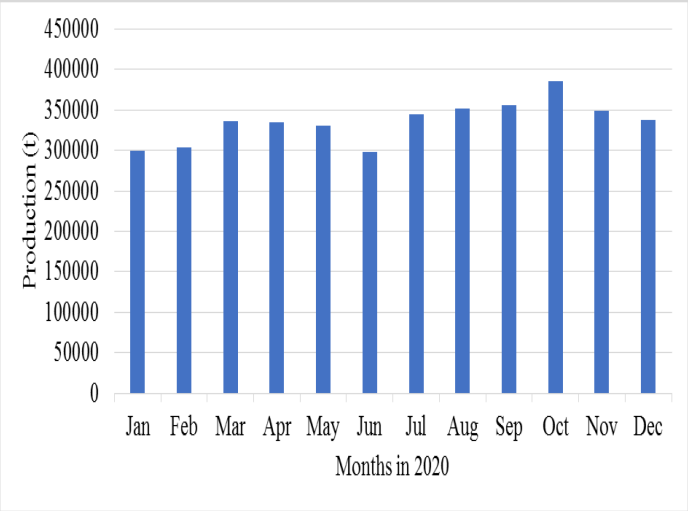



**Figure 2** Monthly ore production tonnage for the Year 2020

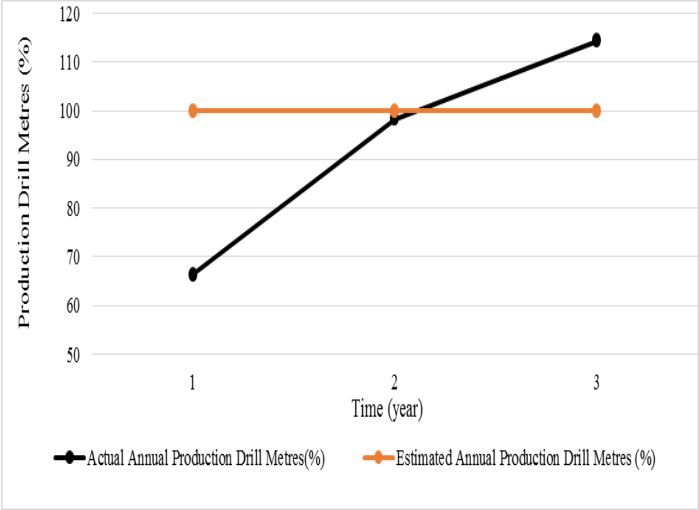



**Figure 3** Actual and estimated production drill metres versus time

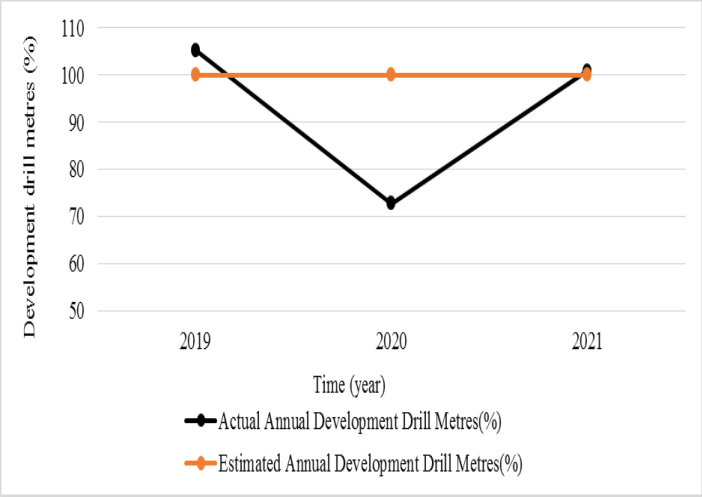



**Figure 4** Actual and estimated development drill metres versus time

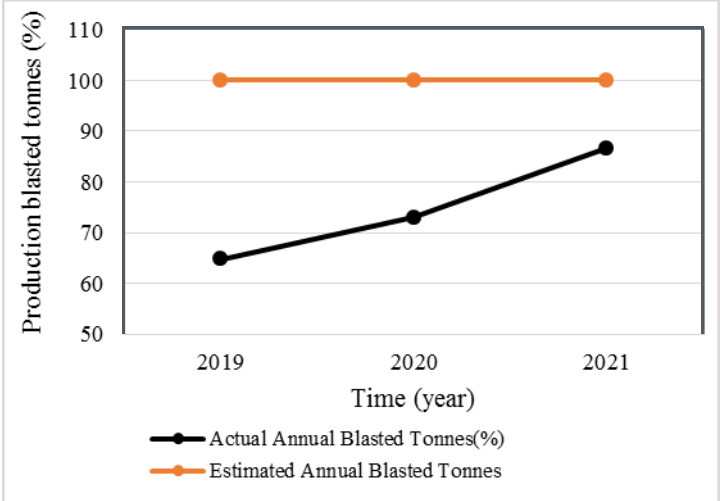
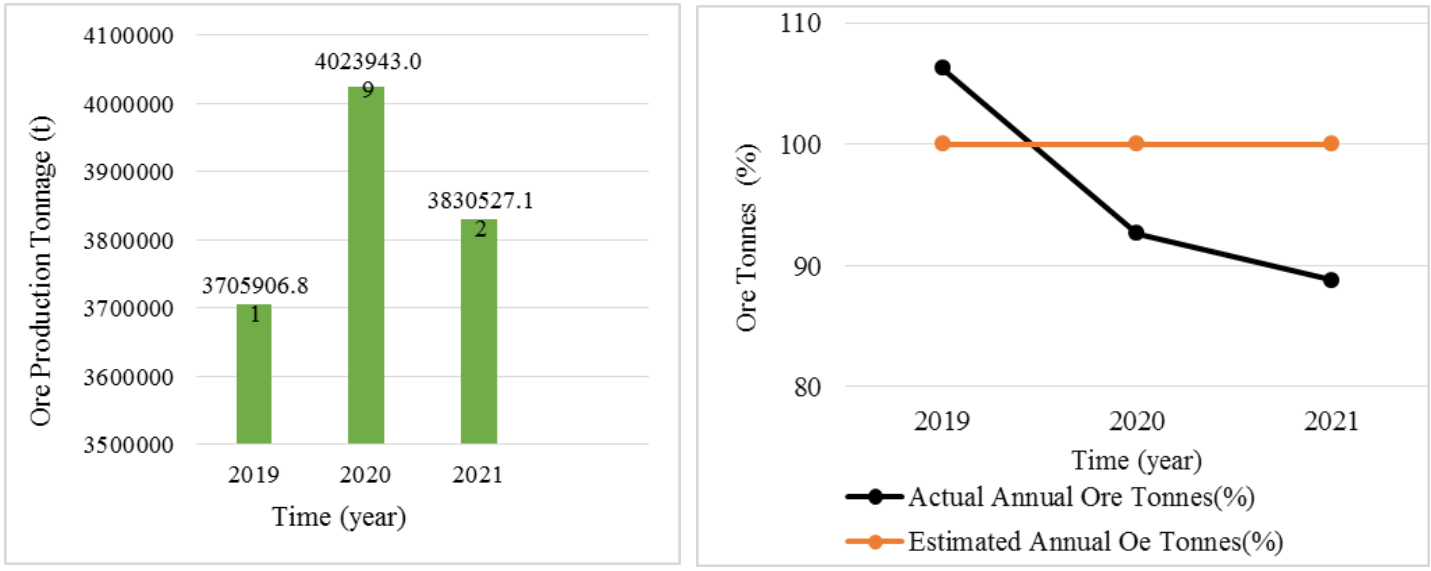



**Figure 5** Actual and estimated production blasted tonnes against time




(a) (b)

**Figure 6** The (a) annual ore production tonnage rate, and (b) total ore tonnes against time

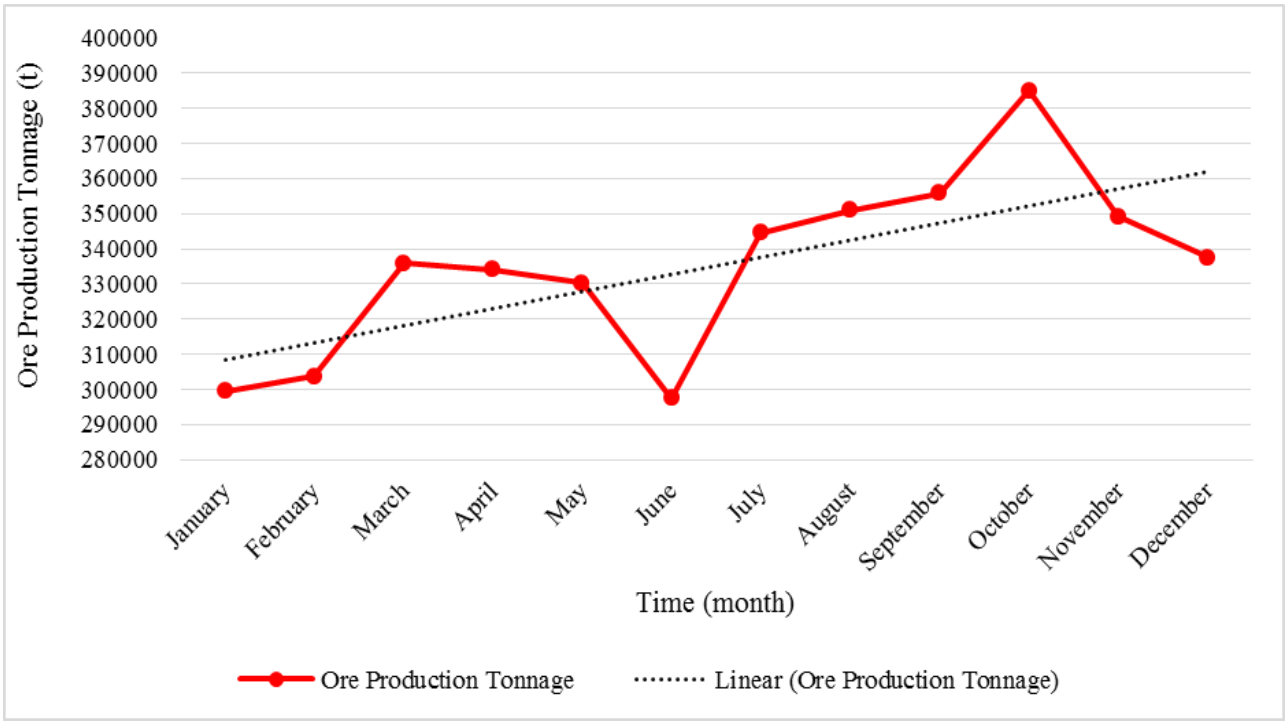



**Figure 7** Trend of the monthly ore production tonnage in 2020

***Production blasted tonnes results and analysis***

From Table 2, 64.74 %, 72.95 %, and 86.70 % of the estimated production blasted tonnes were achieved in 2019, 2020 and 2021, respectively. Figure 5 shows the production trend of blasted tonnes from 2019 to 2021.

***Total ore tonnes results and analysis***

From Table 2, with the total ore tonnes, CGML had an additional increase of 6.24 % of the estimated ore tonnes in 2019. In 2020, 92.61 % of the estimated ore tonnes was achieved, and in 2021, 88.78 % of the estimated ore tonnes was achieved. It is important to note that even though total tonnes declined in 2020, the year had the highest record of ore production tonnage rate compared to the other years. Figure 6a illustrates the annual ore production rate from 2019 to 2021 while Figure 6b presents the trend of the total ore tonnes from 2019 to 2021. The monthly trend of ore production rate in 2020 was analysed and illustrated in Figure 7.

**Discussions**

It can be deduced from Fig. 3 that the production drill metres were fairly good, although 2019 had a very low turnout, while in Fig. 4, the development drill metres were low for 2020, which was attributed to the fact that some of the jumbo drills were not functional and hence unavailable to be used. In Fig. 5, the blasted tonnes for 2019 were relatively low. Two of the six underground mines, the Akwaaba mine and the Paboase mine, used the Sublevel Caving Mining Method in 2019. The reason being that, in Sublevel Caving, all the blasted ore in the stopes is not retrieved immediately. A percentage of the blasted ore is retrieved from the stope, and the remaining ore is left in the stope mainly to provide stability to the stope, while ore that is left on the sublevels above caves in gradually as the mine increases in depth. The percentage of ore left in each stope is retrieved as the levels advance and the mine approaches closure; this implies that the quantity of the blasted tonnes recorded in 2019 was low because a percentage of the blasted tonnes was not retrieved from the blasted stopes.

In 2020, the Akwaaba mine switched to Sublevel Stoping, where all the blasted tonnes are retrieved from the blasted stope. By 2020, both the Paboase and Akwaaba mines had been worked to a higher depth, and both were scheduled to shut down within the next few years. The ore retrieved after a stope is blasted in the sublevel caves was therefore increased relative to the previous year. According to the CGML mine planner, the percentage over bog for the sublevel caves was 180 % in 2020. The percentage over bog refers to the percentage of material retrieved from the stopes in the sublevel caves. Personnel were tasked to draw out the ore till traces of waste material could be seen. From Fig. 6, the ore tonnes for the three years did not vary much, with 2020 recording the highest value. From Fig. 6, the annual ore production tonnage rate was fairly good throughout the three consecutive years. The ore production tonnage in 2020 was the highest recorded in the three-year data acquired for the study.

According to the medical doctor of CGML, the first confirmed case of the Covid-19 virus was in April, and the most positive cases recorded were between April and July. However, the monthly trend of the ore production rate did not vary greatly within these crucial months of the pandemic except for June, which had the lowest monthly ore production value for the company in 2020 (Fig. 7). This was because a number of the blasted stopes had bridged, so the broken tonnes underground in that month decreased. The greatest effect the pandemic had on the company was on the working personnel of the company. In determining the yearly targets, the mine planners did not view the Covid-19 disease as a threat to the underground operations in CGML since it was not globally known as a pandemic at the start of 2020. CGML operated three working shift hours, each consisting of eight hours daily.

During the wave of the pandemic in Ghana, one working shift personnel were laid off, and CGML operated with two working shift hours where each shift worked for twelve hours daily. This was the strategy the mine employed in the wake of the pandemic. When the number of working personnel was reduced during the Covid-19 surge year, it was logical for the mine to run at lower values in production. However, the workers were motivated by the then-current condition of the mine and worked harder to sustain their employment. Subsequently, the ore production tonnage rate was very high during the Covid-19 surge era. The new shift instituted to control the pandemic outbreak caused fatigue among the working personnel; the company, however, placed a few measures in place to manage fatigue among the workers. One such measures was a longer off-work days period. After the pandemic surge declined, the three working shift hour routine was reinstated in the underground department of the mine. The variations in the values of most of the parameters analysed was accounted for by other operational factors such as the choice of mining method, unavailability of some equipment and stope bridges other than the wave of the pandemic. There is a possibility that if the three working shift regime was in effect during the pandemic era, the values for the 2020 year might have increased above what the year recorded. Nevertheless, the 2019 and 2021 trend of values recorded disproves that the mine would have automatically increased beyond what was actually recorded in 2020.

## Conclusions

After conducting the analysis, it was found that the Covid-19 pandemic surge did not have a significant effect on the primary underground production operations at CGML. However, the pandemic surge had a negative impact on the underground operations department's workforce. Notwithstanding, the ore production rate over the pandemic period was high due the measures put in place to maintain production levels.

To mitigate the inefficiencies caused by some workers, it is recommended that CGML adopt automated machinery and equipment in its operations to enhance productivity levels and compensate for any inadequacies caused by the workers. Additionally, management should ensure that the machinery and equipment are available during working hours to facilitate smooth and efficient mine operations. It is also necessary to increase supervision and motivation levels to encourage the employees to maintain their productivity levels.

It is worth mentioning that the mine has made significant progress in implementing the two working shift system, but it is logical to conclude that a three working shift system would have performed better under the same conditions. Therefore, management should consider increasing the number of working shift personnel back to three to enhance productivity levels further in future in an event of unforeseen occurrence. Furthermore, in light of the potential impact of future pandemics, it is crucial that the management develop contingency or provisions for the work schedule of employees to ensure smooth operations during future pandemics or other unforeseen crises.

## Conflicts of Interest Declaration

The authors declare no conflict of interest.

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