












## Trends of in-hospital maternal mortality during the COVID-19 pandemic in southern Morocco – analysis of a time series from 2016–2022

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### ABSTRACT

**Introduction and aim.** The aim of this study was to compare trends of in-hospital maternal mortality in southern Morocco before and after the COVID-19 pandemic emerged in the Kingdom in March 2020.

**Material and methods.** We conducted a retrospective study of a time series of hospital maternal deaths from January 2016 to December 2022. Data were collected from maternal death registers and monthly reports from maternity departments of six public hospitals in Souss Massa region (one regional and five provincial hospitals).

**Results.** 216 maternal deaths occurred during the study period, 112 before and 104 during the pandemic. The highest annual maternal mortality ratio (MMR) was observed in 2021 (207.41 deaths/100,000 live births). Trends of monthly MMR showed a significant increase during the pandemic compared with the pre-pandemic period ( $p=0.002$ ). Furthermore, an extremely high MMR value (977.57/100,000 live births) was noted in August 2021 (the Delta wave).

There was a significant difference in the distribution of causes of maternal death. Proportion of indirect causes were tripled during the pandemic (from 8% to 24%), with 17/104 (16.3%) deaths related to SARS-CoV-2 pneumonia.

**Conclusion.** In-hospital MMR increased in public hospitals of the Souss Massa region during the COVID-19 pandemic, particularly in the third quarter of 2021.

**Keywords.** COVID-19 pandemic, maternal mortality, southern Morocco, time series

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## Introduction

The tenth revision of the International Classification of Diseases (ICD-10) defines maternal death as the death of a woman during pregnancy, childbirth or the postpartum period, from any cause related to or aggravated by the pregnancy or its management.<sup>1</sup> A WHO systematic analysis indicated that hemorrhages, gestational hypertensive diseases, and sepsis were the main causes of maternal death worldwide. While indirect causes accounted for more than 25% of causes.<sup>2</sup> Several factors increased the risk of maternal death, such as maternal age over 35 years (OR=2.63).<sup>3</sup> Avoidable deaths were not completely attributable to pregnancy complications, they were also related to socio-economic factors and healthcare efficiency.<sup>4</sup>

The maternal mortality ratio (MMR) is an indicator of healthcare quality, whose reduction is a major global challenge.<sup>5</sup> It is defined as the number of maternal deaths during a given period per 100,000 live births (LB) during the same period.<sup>1</sup> Over the last few decades, the MMR has decreased worldwide, although there were disparities between countries depending on their income levels and maternal health policies.<sup>6</sup> Indeed, maternal death is an uncommon outcome in high-income countries, mainly linked to pre-existing chronic conditions. While it is more common in low-income countries, due to lack of access to skilled maternal healthcare.<sup>7</sup> Pregnancy related mortality was also found higher in rural than in urban areas even in high-income countries such as United States.<sup>8</sup>

Morocco is a developing country that has adopted several policies aimed to improve maternal and perinatal health. It achieved a decrease of 69.9% in maternal mortality ratio over the period 2000-2020, falling from 244 to 72.6 deaths per 100,000 live births. An MMR lower than global estimates for the North Africa region for 2020 (103 deaths/100,000 live births).<sup>9</sup> This performance meets the WHO's Agenda 2030 target (to reduce maternal deaths to less than 70 per 100,000 live births).<sup>10</sup> Consequently, Morocco is at stage 4 of the maternal mortality transition (MMR <100), whereas it was at stage 3 (MMR 0–299) in 2000.<sup>4</sup> Although several official reports have been published on maternal mortality in Morocco, few local studies have examined causes of deaths.<sup>11</sup>

The Souss Massa region was merged with the Daraa region in southern Morocco before the 2015 territorial organization. According to the report of the confidential survey of maternal deaths, Souss Massa-Daraa was the leading region in terms of pregnancy-related deaths.<sup>12</sup> This national survey, report that 79% of maternal deaths occurred in public hospitals. The Moroccan report 'Health in figures' for the year 2022, indicated that the rate of childbirth in public facilities was around 56%, 83% of which were recorded in public hospitals.<sup>13</sup>

The emergence of the COVID-19 pandemic has reduced the progress achieved in public health and caused an excess of mortality rates worldwide.<sup>14</sup> This fact prompts to examine the effect of this pandemic on maternal mortality rates and causes. Initially, as a direct consequence of pregnant women contamination by SARS-CoV-2.<sup>15</sup> Furthermore, as an indirect result of the healthcare services perturbation.<sup>16</sup> A systematic review reported an increase of maternal mortality rate compared with the pre-pandemic period (RR=1.37).<sup>17</sup> The World Health Organization has stated that the COVID-19 pandemic may have contributed to the lack of progress on reduction of MMR. However, it was not possible to comprehensively assess this impact, as published global data on maternal mortality during the pandemic were limited and mainly concerned high-income countries.<sup>9</sup>

Morocco, in turn, was not exempt from of the COVID-19 pandemic consequences. Just one year after the first case appeared on March 2020, more than 9,000 deaths have been reported, despite the several measures implemented to reduce the impact of the COVID-19 pandemic on public health.<sup>18</sup> Indeed, the Moroccan government has adopted a strategy based on prevention of the SARS-CoV-2 transmission.<sup>19</sup> Regarding perinatal health, the Ministry of Health has circulated an urgent notice requesting healthcare workers to ensure the usual activity of maternal care services during the pandemic.<sup>20</sup> To this aim, a digital platform was created to promote prenatal monitoring during the lockdown with the possibility of face-to-face consultations, imposing protective masks. Priority was given to pregnant women for PCR testing, particularly during the screening and admission procedure. Furthermore, specific care channels were introduced in hospitals for pregnant women with confirmed or suspected COVID diagnosis to reduce the risk of hospital-acquired infection. The organizational diagrams for cases management, diagnosis procedures, and therapeutic protocols were detailed in a national guide, published in May 2020.<sup>21</sup>

## Aim

In order to improve the evidence on the impact of COVID-19 on maternal mortality, the aim of this study was to assess trends of in hospital MMR in Souss Massa region in southern Morocco during the COVID-19 pandemic relative to pre-pandemic period. The secondary objective was to compare causes of death, age, and geographical origin of deceased women in both periods.

## Material and methods

### *Type and period of the study*

We conducted a comparative multicentric, retrospective study of a time series of maternal deaths occurring in

public hospitals of the Souss Massa region over seven years, extending from January 2016 to December 2022.

### Study setting

The Souss-Massa region has been one of Morocco's 12 regions since the 2015 territorial reorganization. It is located at the junction of the north and south of the country. The region covers 7.6% of the national territory, including 6 provinces: Agadir Ida Outanane, Inezgane Ait Melloul, Taroudant, Tiznit, Chtouka Ait Baha, and Tata. The rural area is extensive in the region (154 rural versus 21 urban communes). According to the High Commission for Planning, urban population is estimated in 2022 at 1881521 and rural population at 1095607 (Detailed presentation of the region is available on the website [www.hcp.ma](http://www.hcp.ma)). As for public healthcare provision in the region, there are 198 physicians and 304 specialists. There are 2,466 nurses and health technicians, including 517 midwives. The maternal health care programs target 446,917 childbearing women. In 2022, 16.66% of deliveries in the public sector were carried in primary maternity facilities and 83.33% in hospitals. The private sector is competitive, number of privately owned clinics in the region is 24 with 293 physicians and 460 specialists.<sup>13</sup>

This regional study was conducted in public hospitals in Souss Massa: the Agadir regional hospital, which receives patients from all over the region, and is also the COVID-19 reference hospital. And the five provincial hospitals proper to each of the remaining provinces. These hospitals were provided with units of isolation and management for suspected and confirmed COVID-positive pregnant women. However, critical cases were transferred to the regional hospital when required.

### Study eligibility criteria

#### Inclusion criteria

The maternal death notification system was introduced in Morocco in 2009 notify any death of a woman aged between 15 and 49 in each province. Monthly reports were performed including main feathers of deceased women. Confidential audits then determine the main cause and whether it was a maternal death.<sup>12</sup> The current series included women aged between 15 and 49 years who died in hospital during pregnancy, childbirth, or post-partum, for obstetric or non-obstetric reasons. This was an exhaustive collection of all cases of maternal deaths over the period 2016–2022, in the six public hospitals of the region.

#### Exclusion criteria

The study excluded: 1) deaths that do not meet the definition of maternal death, 2) deaths occurring before admission to hospital.

Private clinics were excluded from our study given that pregnant women admitted there were commonly transferred to regional public hospitals in event of major complications.<sup>22</sup>

### Data sources

This study was carried out with the authorization of the Regional Health and Social Protection Directorate in the Souss-Massa region.

The data collected for this time series were based on maternal death registers from the maternity departments in the included hospitals and monthly reports of these maternity departments.

### Outcomes and data collection process

The first case of SARS-CoV-2 infection was recorded in Morocco on March 2, 2020. It was followed by the Moroccan government's declaration of a state of public health emergency and restrictions in response to the pandemic. These measures were lasted for three years and periodically updated according to the epidemiological situation in the kingdom.

In this study, pre-pandemic maternal trends were described to provide a baseline for comparing changes after the emergence of COVID-19.

The pre-pandemic period was defined from January 2016 to February 2020.

The post-pandemic period was extended from March 2020 to December 2022.

Data collected in the present study were those recorded monthly in registers of hospital maternal deaths. These included serial number of maternal death, date of death, maternal age, province, area of residence (urban or rural), location of death (hospital department), and cause of death. A compilation sheet was used to extract individual data from the registers for each case included on the time series.

Maternal causes of death were defined according to the International Classification of Diseases (ICD-10), excluding causes of late maternal death:<sup>1</sup>

Direct causes: Hemorrhage, hypertensive disorders, sepsis, obstetric embolism...

Indirect causes: SARS-CoV-2 infection, other maternal diseases complicating pregnancy, childbirth, and the postpartum period.

The authors classified the causes of death based on what was notified on the maternal death registers. It should be noted that the primary cause is the one that is listed after the audit decision.

Monthly in hospital MMR were calculated using the following formula: *Monthly MMR = (Number of maternal deaths occurring in hospital settings during a given month / Number of live births in the same month in the same hospital settings) × 100,000*

The annual in hospital MMR was calculated for each given year.

$Annual\ MMR = \frac{\text{Number of maternal deaths occurring in hospital settings during a given year}}{\text{Number of live births in the same year in the same hospital settings}} \times 100,000$

The number of live births (LB) was extracted from the monthly statistical reports issued by each hospital's maternity department. It was then summed to estimate the monthly number of live births for all included hospitals. The annual number of live births was calculated using the sum of the monthly number of live births in all hospitals for each year.

Similarly, the number of maternal deaths was calculated monthly and annually based on cases notified on the maternal mortality registers for each hospital. It was then summed to estimate the overall number of deaths occurring in the included hospitals per month and per year.

### Statistical analysis

The analysis method used was a comparative model of pre- and post-pandemic MMR on a time series. This model is also used to examine characteristics of deceased women.

The categorical variables were presented as numbers and percentages. The age group, area of residence, and site of death were compared using the chi-square test ( $\chi^2$ ) or Fisher's exact test, depending on the application conditions of each test.

The normality of the distribution was verified with the Shapiro-Wilk test, the MMR was a continuous variable with a non-Gaussian distribution. Therefore, the central tendency was described using the median and interquartile range for each period. The pre and post pandemic MMR medians were compared using the non-parametric Mann-Whitney test.

Combined curves were adopted to illustrate changes in MMRs, maternal deaths, and live births over time. Additionally, the geographical distribution of deaths was mapped using ArcGIS 10.8 software.

Data were entered and analyzed using the statistical software Jamovi version 2.3.28. A p-value <0.05 was considered statistically significant.

### Ethical considerations

This study was conducted respecting the ethics and dignity of the participants. Ethical approval was granted by the Ethics Committee for Biomedical Research of the Faculty of Medicine and Pharmacy Mohammed V in Rabat (Reference: CERB G/23). In this study, the ethical standards of the institutional and/or national research committee were applied in all procedures performed involving human participants. Confidentiality and anonymity criteria were respected as charted by the Declaration of Helsinki and its later amendments.

## Results

### Trends in in-hospital MMR in the Souss Massa region before and during the COVID-19 pandemic

As showed in figure 1, the in-hospital MMR in the Souss Massa region decreased between 2016 and 2017 by 35.7%. It then increased by 36.2% and 47.8% in 2018 and 2019 respectively. During the COVID-19 pandemic, the MMR declined slightly in 2020 (131.6 deaths/100,000 live births) and then increased significantly in 2021, with 207.41 deaths/100,000 live births. And it achieved 156.06 per 100.000 live births in 2022. Number of maternal deaths was variable over the study period. The highest value was recorded in 2021 (44 deaths) and the lowest in 2017 (26 deaths). In terms of live births (LB), there was a gradual decline. there has been a gradual decline. It fell from 28062 to 25557 in 2016-2019, and from 22792 to 21145 in 2020-2022 (Fig. 1).

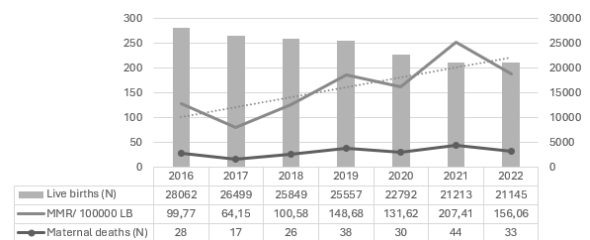


Fig. 1. Annual trends of MMRs, maternal deaths, and live births in SOUSS MASSA region hospitals from 2016 to 2022

The median monthly of MMR in the pre-pandemic period was 93.3 (81.7-125) deaths/100,000 LB. During the COVID-19 pandemic, the median was 116 (101-207) deaths/100,000 LB. The comparison of medians showed a significant increase in MMR relative to the pre-pandemic period ( $p=0.002$ ). A peak was noted in August 2021 with an extremely high MMR value (977.57 deaths/100,000 live births). Another increase was noted in May 2020 (359.89 deaths/100,000 live births). In addition, the highest number of maternal deaths was recorded in August 2021 (17 deaths). However, no deaths occurred during in January and October 2017. The number of live births fluctuated, showing a declining trend throughout the pandemic. The minimum value was recorded in February 2021 (147 LB), and the maximum value (2593 LB) was noted in June 2017 (Fig. 2).

Figure 3 showed that the province of Taroudant had the highest frequency of maternal deaths before and after the pandemic, while Tiznit and Tata were the least affected. Maternal deaths in the province of Inezgane Ait Melloul increased by 46% during the pandemic.

### Distribution of maternal deaths by age, area of residence, site, and cause of death

Table 1 showed that the indirect causes were more frequent during the pandemic. Of the 104 mater-

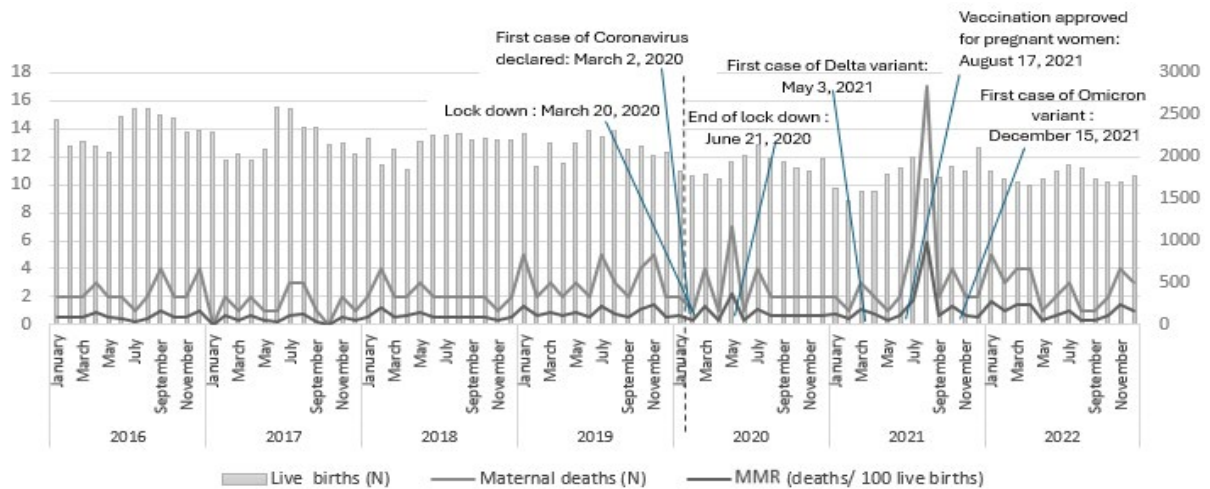


Fig. 2. Monthly trends of MMRs, maternal deaths, and live births in Souss Massa hospitals from 2016 to 2022

nal deaths recorded during the pandemic, 17 deaths (16.3%) were caused by SARS-CoV-2 infection. However, hypertensive disorders (eclampsia, pre-eclampsia, HELLP syndrome) were the leading cause of maternal death, representing respectively 37.5% and 34.8% of direct causes during the pandemic and pre-pandemic periods.

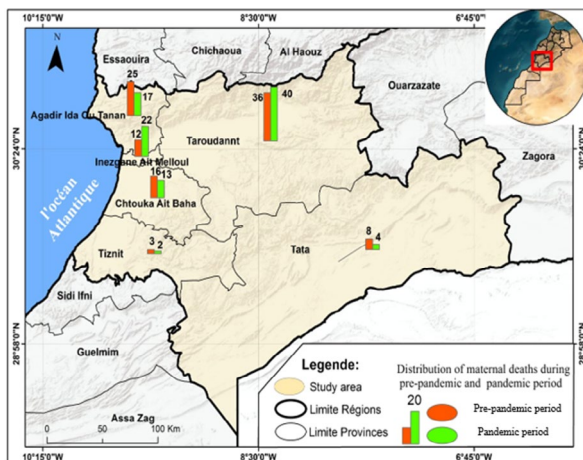


Fig. 3. Spatial distribution of hospital maternal deaths in the Souss Massa region by province of origin

The mean maternal age was  $31.4 \pm 6.8$  years in the pre-pandemic and  $32.1 \pm 6.8$  years during the pandemic. There was no significant association between the pandemic period and the distribution of maternal deaths, either by age group or by area of residence ( $p > 0.05$ ). Most maternal deaths occurred among women aged over 35 and those living in rural areas for both periods (Table 1). A significant association was observed between the COVID-19 pandemic and the hospital setting of maternal death ( $p = 0.005$ ). Intensive care units were the departments where the greatest number of deaths occurred (75.9% and 65.4% before and after

the pandemic respectively). 12 deaths occurred in a specific COVID-19-unit care (Table 1).

Table 1. Distribution of maternal deaths before and during the COVID-19 pandemic by age group, area of residence, site and causes of death\*

Variables	Period (n, %)		p
	Pandemic, n=104	Prepandemic, n=112	
<b>Age</b>			0.395
<35 years	61 (58.7%)	72 (64.3%)	
≥ 35 years	43 (41.3%)	40 (35.7%)	
<b>Area of residence</b>			0.76
Urban	36 (34.6%)	41 (36.6%)	
Rural	68 (65.4%)	71 (63.4%)	
<b>Site of death</b>			0.005
Maternity department	21 (20.2%)	21 (18.8%)	
Intensive care units	68 (65.4%)	85 (75.9%)	
COVID-19 unit care	12 (11.5%)	0 (0%)	
Other site <sup>d</sup>	3 (2.9%)	6 (5.3%)	
<b>Causes of death</b>			
<b>Indirect causes</b>			
Hemorrhage <sup>a</sup>	19 (18.3%)	31 (27.7%)	
Hypertensive disorders <sup>b</sup>	39 (37.5%)	39 (34.8%)	
Sepsis	9 (8.7%)	15 (13.4%)	
Other obstetric causes <sup>c</sup>	12 (11.5%)	18 (16.1%)	
<b>Indirect causes</b>			
SARS-CoV-2 infection	17 (16.3%) <sup>†</sup>	0 (0%)	
Other indirect causes <sup>d</sup>	8 (7.7%)	9 (8%)	

\* <sup>Δ</sup> – operating room, emergency department, <sup>a</sup> – all types of obstetric hemorrhage, including hemorrhage due to uterine rupture, <sup>b</sup> – eclampsia, pre-eclampsia, HELLP syndrome, <sup>c</sup> – thromboembolic complications, post-surgical complications, unspecified obstetric cause, <sup>d</sup> – all non-obstetric causes: diabetes, meningitis, cholecystitis, pancreatitis, <sup>#</sup> – including one death due to pre-eclampsia complicated by SARS-CoV-2 infection

Of the 17 deaths linked to maternal infection with SARS-CoV-2, 2 deaths occurred at the start of the pan-

demic (April-May 2020), 12 deaths during the months of July-August 2021, corresponding to the Delta wave, and one death in December 2021 (Omicron wave).

## Discussion

The present study indicated that there was a significant increase in hospital MMR in Souss Massa region during the COVID-19 pandemic compared to the previous four years. This increase was not pronounced at the start of the pandemic, whereas it was catastrophic at the third quarter of 2021, with a peak of maternal deaths in August. That occurred even though the Moroccan Ministry of Health has introduced preventive measures in hospitals to improve care for infected pregnant women. There was a specific circuit for women with a positive or suspected diagnosis. After admission, they were hospitalized and constantly monitored in an isolation room. A therapeutic protocol was dispensed depending on gestational age, co-morbidities, and the severity of COVID-19 disease. Laboring women were referred to a specific delivery room, if a caesarean section is indicated, they are transferred to the appropriate operating room and then returned to the isolation unit. Women with severe symptoms were transferred to the COVID-19 reference intensive care unit. In contrast, pregnant women defined as negative were oriented to the usual process. However, monitoring and reporting of any emergent symptoms were strongly recommended. After discharge, an extensive disinfection of areas was systematically performed.<sup>21</sup>

The increase of MMR during the pandemic could be explained by multiple factors, especially the rise of maternal deaths. Indeed, in our study, the highest number of deaths was recorded in 2021. Similarly, the fall of births and live births in public maternity units may be an important determinant. According to the official annual reports 'Health in figures' (available on the website of the Ministry of Health and Social Protection [www.gov.ma](http://www.gov.ma)), the births in public hospitals of Souss Massa fell from 2017 to 2022. There was a decline of 3.76% in 2017–2019 period and 9.8% during the pandemic (2020–2022). The lowest values were noted in 2021 and 2022, which may also explain the decrease observed in live births in current study. The fall in hospital births could be considered as an indirect effect of the pandemic on the use of maternal health services, as indicated in literature.<sup>23</sup>

In Morocco, the Delta wave was the severest, affecting 10,000 patients daily, nationwide. The pandemic peaked in August, when intensive care units reached maximum capacity, health workers burned out, and an excessive use of oxygen was reported.<sup>19</sup> In our series, of 17 maternal deaths due to SARS-CoV-2 infection, 12 deaths occurred during the Delta wave (July–August 2021). A meta-analysis of studies conducted at

the start of the pandemic reported that maternal mortality rates were reassuring.<sup>24</sup> Similarly, a Turkish study indicated that in-hospital maternal mortality related to SARS-CoV-2 infection was high during the Delta wave (7%) compared to other pandemic stages (1.28% in the first wave and 2.56% in the Omicron wave).<sup>25</sup> In contrast, a high incidence of maternal deaths was observed at start of the pandemic in some countries such as Brazil and Mexico.<sup>26</sup> A Mexican study reported a 56.8% increase of MMR in 2020.<sup>27</sup>

The lack of vaccination of pregnant women against COVID-19 could explain associated maternal deaths.<sup>25</sup> The Delta variant was reported to increase maternal mortality and admissions to intensive care units, particularly in unvaccinated pregnant women.<sup>28</sup> Indeed, the rise of maternal deaths incidence during the Delta wave prompted the Moroccan Ministry of Health to publish a circular on 17 August urging the vaccination of pregnant women against SARS-CoV-2.<sup>29</sup> This could explain the relative decline in MMR over the next month. Furthermore, the universal application of health insurance in Morocco, at the end of 2021–beginning of 2022, could improve equity of access to healthcare services.<sup>30</sup>

The annual MMRs were high in our results compared to the latest national data published in 2018 (72.6 deaths per 100,000 LB).<sup>13</sup> Nevertheless, they remained lower than the estimated global MMR in 2020 (223 deaths per 100,000 LB). This can be explained by the exclusion of primary maternity units, private clinics, and home births which account for around 40% of births in Morocco. Consequently, the results obtained were based solely on live births in public hospital maternity units.

Intra-regional disparities were noted in current study. Women living in the province of Taroudant had the highest incidence of maternal death, which could be explained by rurality and its impact on access to qualified care. This province contains only 8 urban communes, against 81 rural communes. The greatest increase in maternal deaths during the pandemic was noted in the province of Inezgane Ait Melloul, the most densely populated province in the Souss Massa region (2,168 inhabitants per km<sup>2</sup>). That might increase the risk of pregnant women exposure to SARS-CoV-2 (Detailed presentation of the Souss Massa provinces is available on the website [www.hcp.ma](http://www.hcp.ma)).

Our case series showed that no significant difference in maternal age or residence area between the pre-pandemic and pandemic period. Most maternal deaths occurred among women aged over 35 and those living in rural areas for both periods. It is reported that the effect of age on maternal mortality rate is intensified by rurality.<sup>8</sup> This rate is 2.5 times higher in rural areas than in urban areas in Morocco.<sup>31</sup> In a large American cohort study, COVID-19-related mortality was found to be associated with maternal age over 35 years (RR=23.9).<sup>32</sup>

Co-existing conditions and socioeconomic vulnerability increase this association.<sup>33</sup>

The present study showed that indirect causes of maternal death was tripled during the pandemic (from 8% to 24%) due to deaths related to SARS-CoV-2 pneumonia. Hypertensive disorders remained the principal cause of maternal death in Souss Massa region with a slight growth of 2.7% during the pandemic. A Canadian cohort study showed that the incidence of pre-eclampsia did not increase significantly during the first 18 months of the pandemic.<sup>34</sup> However, it was reported that pregnant women with pre-eclampsia were vulnerable to COVID-19 complications.<sup>35</sup> In our case series, one death was due to severe pre-eclampsia associated with SARS-CoV-2 infection. In addition, intensive care units (ICU) continued to be the main site of maternal deaths even during the pandemic. This is consistent with the Moroccan confidential maternal death survey findings, in which 74% of hospital deaths occurred in ICU, followed by maternity unit.

There were considerable disparities in the maternal health impact of the pandemic between high and middle/low income countries.<sup>17,36</sup> To mitigate this situation, priority must be given to equitable access to quality maternal and perinatal healthcare.<sup>17</sup> Reducing urban/ rural disparities should be a strategic goal in maternal health policies.<sup>8</sup> To accomplish this objective, it is essential to raise the rural population awareness on the importance of maternal health care. Furthermore, mapping disparities would help to identify the most vulnerable areas and to implement effective solutions.<sup>37</sup> Several recommendations can be proposed to reduce maternal mortality as enhancing the monitoring system of maternal death and perinatal care quality, and improving horizontal and vertical communication between stakeholders.<sup>38</sup> In addition, it is crucial to standardize management procedures for severe obstetric complications through validated protocols.<sup>22</sup> In terms of human resources, Morocco needs to recruit 760 midwives each year to improve coverage to 95%, according to the International Confederation of Midwives. This should contribute to reducing the incidence of maternal deaths and stillbirths by 2030.<sup>39</sup> Moreover, resorting to public/private partnerships may optimize the human and material resources.<sup>40</sup>

#### *Study limitations and strengths*

The current study was the first in Morocco addressing the longitudinal effect of the COVID-19 pandemic on maternal mortality in a large Moroccan region over seven years, from 2016 to 2022. This descriptive and comparative analysis provided an overview of trends in maternal deaths and live births in public hospitals in the context of the COVID-19 pandemic.

However, the study has several limitations. Collected data were limited to the maternity unit registry and

did not include the medical records of deceased women. That excluded important variables which only available on records as timing of maternal death, comorbidities, parity, prenatal care, socioeconomic status, vaccination status, and data regarding the health care quality. Exploring these variables would have allowed a more precise interpretation of the findings.

The representative of the number of maternal deaths should be treated with caution, due to the probability of under-reporting of maternal deaths, particularly outside public health care structures. Furthermore, the series only included maternal deaths occurring in public hospitals. As a result, live births in these sites were considerably lower than live births in all public and private health facilities in the region. This weakness explains the general increase in hospital MMR compared TH national statistics.

Despite the limitations, the findings can enhance understanding the effect of the COVID-19 pandemic on maternal mortality in developing countries. In addition, they can provide a useful roadmap for public health decision-makers in developing strategies to strengthen maternal health and reduce disparities in access to health care.

#### **Conclusion**

The hospital MMR increased in the Souss Massa region during the pandemic, particularly in the third quarter of 2021. Infection with SARS-CoV-2 during pregnancy appears as a new indirect cause of maternal death, this cause was more frequent during the Delta wave. Women aged over 35 and those living in rural areas were most at risk of maternal death during both the pandemic and pre-pandemic periods.

Although the increase observed in the MMR during the pandemic was significant, it is not attributable to a sole factor. Further investigations are recommended to determine all associated factors. Updating published data on national and regional maternal mortality will allow for more understanding of the effect of the pandemic, and improved management of preventable causes of maternal death.

#### **Declarations**

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##### *Author contributions*

Conceptualization, K.O., R.R. and M.O.; Methodology, K.O., L.L., and M.O.; Software, M.A.B.; Validation, K.O., R.R., A.K. and M.O.; Formal Analysis, K.O. and A.L.; Investigation, K.O. and M.O.; Resources, None.; Data Curation, K.O. and S.M.; Writing – Original Draft Preparation, K.O.; Writing – Review & Editing, K.O., R.R., A.L., S.M., S.E.H., A.K. and M.O.; Visualization,



K.O., R.R., S.M and A.K.; Supervision, M.O.; Project Administration, A.K.

### Conflicts of interest

The authors declared no conflicts of interest for this paper.

### Data availability

Data available on request from the authors.

### Ethics approval

The ethical approval was granted by the Ethics Committee for Biomedical Research of the Faculty of Medicine and Pharmacy Mohammed V in Rabat, Morocco (Reference: CERB G/23).

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