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Original article

COVID-19 home monitoring program: Healthcare innovation in developing, maintaining, and impacting the outcome of SARS-CoV-2 infected patients

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ABSTRACT

Introduction: The Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) had caused an increased burden on healthcare organizations. Thus, a new strategy is needed to ensure all COVID-19 positive cases appropriately followed up , to receive the proper medical and psychological support, and to comply with the isolation guidelines. Here, we describe the characteristics and outcome of COVID-19 patients who were managed at home. In addition, we describe the differences between asymptomatic and those with mild symptoms.

Materials and methods: This is descriptive study of all COVID-19 positive cases who were monitored utilizing the home care concept.

Results: During the study period from June 8 to October 18, 2020, there was a total of 5368 COVID-19 patients who were referred to the home isolation/monitoring program. Of those, 2397 (45%) were female and 2971 (55%) were male. Of the total cases, 295 (5%) required hospital admission, 45 (1%) were admitted to zone 2 (an intermediate care facility), and the majority 5028 (94%) were continued in the home monitoring program till recovery. Of the total cases, 3137 (59%) were asymptomatic and the remaining 41% were symptomatic. Asymptomatic patients in comparison to symptomatic patients showed significant differences in relation to mean age (+ SD) of 31.5 (+ 18.6) and 46.45 (+ 17.1), respectively ($P < 0.001$)), gender, being healthcare workers, and the presence of significant medical conditions. However, a logistic regression analysis showed that only age and the presence of diabetes mellitus were associated with the presence of symptoms. The mean age (±SD) of those who required hospital admission was higher than those who were continued in home monitoring or cared for in zone 2.

Conclusion: The utilization of home monitoring program was effective and safe in patients who were either asymptomatic or had mild symptoms.

1. Introduction

Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) caused the current pandemic since its emergence in December 2019 in Wuhan city, China [1,2]. Three months later, initial cases of the Coronavirus Disease 19 (COVID-19) were reported in the Arabian Gulf Countries [3,4]. Similarly, the first case in the Kingdom of Saudi Arabia (KSA) was reported on March 2nd, 2020 and since then the number of COVID-19 cases increased over the following months and peaked in June–July 2020. As precautionary measures, all returning travelers to KSA were required to be quarantined in designated hotels [4]. Such quarantine was very demanding with low positivity rates. One study from KSA showed that 1.2% of 1918 returning travelers tested positive for SARS-CoV-2 [4]. Similarly, in another study from Bahrain, 0.6% of 10,449 travelers who entered quarantine facilities tested positive for SARS-CoV-2 [5]. In KSA, initial cases of SARS-CoV-2 patients were required to be admitted to the hospital irrespective of the presence or absence of symptoms [6]. Globally, COVID-19 had also resulted in a

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great disparity in the outcome as it relates to gender and minorities [7] in addition to the unique characteristics of COVID-19 patients in rural and urban communities [8]. At a time when the pandemic is raging in several parts of the world with overcrowded hospitals and scarce beds, many of the patients with high risk factors for progression but not sick enough to be in the hospital may benefit from home monitoring. Patients being discharged from the hospital could also be ideal candidates for such approach. Moreover, the majority of COVID-19 cases are either asymptomatic or have mild symptoms. Thus, there is a need for a new strategy to manage those patients and to ensures all COVID-19 cases appropriately followed up to receive proper medical and psychological support, and to comply with the isolation guidelines in order to prevent the spread of the infection. Thus, KSA allowed patients who did not need admission for clinical indications to be managed at home. In this study, we describe the characteristics and outcome of COVID-19 patients who were managed at home. In addition, we aimed to describe the differences between asymptomatic and those with mild symptoms.

2. Materials and methods

The study included all positive SARS-CoV-2 patients who were diagnosed in the ambulatory setting as well as in the emergency department and were deemed not needing admission at the time of the presentation. The study took place at the Johns Hopkins Aramco Healthcare (JHAH). JHAH provides medical care to about 200,000 eligible medical recipients including Saudi Aramco employees and their dependents. Home monitoring program for COVID-19 positive cases at JHAH was launched on 8th June 2020. The program was a physician-led service with a team including other physicians, case manager, registered nurses, and admin personnel. Upon the receipt of the laboratory results of SARS-CoV-2 PCR tests, these results were forwarded to the case-management admission team for assessment of the patients and to determine suitable disposition (Home Isolation, Zone 2 Facility (a designated hotel) or Hospital admission (otherwise designated as Zone 3). The case management admission team used pre-defined criteria for the disposition of patients as shown in Table 1. In addition, patients with chronic diseases were assessed for home monitoring isolation program on case-by-case basis (Table 2). Home monitoring program was considered for all COVID-19 positive patients who were asymptomatic or had mild symptoms and thus deemed at low-risk of complications.

Patients were regularly followed up to ensure they remained stable and suitable for home isolation. Suitability is determined by the patient's medical condition, other household members' medical conditions, whether home environment is suitable for home isolation, and the ability to download and use the required MOH smart phone applications such as Tatamman (meaning be sure) App and Tawakkalna App (an App that was developed by the National Information Center in collaboration with MOH to aid in the prevention of the spread of COVID-19). These applications help in tracking patients' symptoms and show the status of the individual in relation to the need for quarntine and immunity. The follow-up of patients was conducted via either a telephone consultation or through MyChart visit (part of the electronic medical record (EPIC)). Patients typically received a call on day 1 of enrollment into the program to assess symptoms, medical conditions, home situation, and to ensure they have downloaded relevant smart phone applications (Table 3).

Patients' concerns and questions were addressed, and an explanation was given on what to expect whilst under home monitoring service. Patients received a daily questionnaire via MyChart asking about their symptoms and they were contacted if they answer "yes" to any of the listed symptoms. On day 10, and if they remained asymptomatic for at least 72 h, they were discharged from the service and the patient was issued a clearance as well as his/her status was changed on the MOH database from "Active" to "Recovered".

Table 1
Summary of the Indication for the placement of COVID-19 positive cases in different locations.

	Criteria
For home isolation	• Age <55 years (or ≥55 years with availability of a caregiver) • No history of uncontrolled chronic diseases • Asymptomatic (or mild non-respiratory symptoms eg. Lethargy, body-aches, loss of taste or smell, Nausea) • Suitable home environment for home isolation • Has a smart phone and internet access (able to register in the Ministry of health applications: Tatamman & Tawakalna)
For zone 2 facility (stable patients not suitable for home isolation)	• Fever (controlled with acetaminophen) • Mild upper respiratory infection symptoms: (runny nose, cough, sore throat) • Multiple uncontrolled chronic diseases • Does not require physical assistance (eg. bedridden or wheelchair) • Age <65 years (in good medical condition with stable comorbidity)
For Hospital assessment:	• Unstable condition • Uncontrolled fever • New or worsening Shortness of breath • Chest pain • Hemodynamic unstable due to vomiting and diarrhea with hypotension. • Age >65 yrs with comorbidity

Table 2
A list of chronic diseases considered possibly unsuitable for home isolation as determined by the physician's decision (on case-by-case basis).

Condition	Parameter
Uncontrolled hypertension	>160/100 mmHg
Uncontrolled diabetes Mellitus	HbA1c >9% and on Insulin treatment
Coronary artery disease (CAD)	history of CAD
Morbid obesity	Body mass index (BMI) >40 kg/m^2
Dementia	current
Chronic Kidney Disease (CKD)	stage 4 and 5 (estimated glomerular filtration rate (eGFR) of 15- 29, and < 15; respectively) or on dialysis
Liver diseases	active/cirrhosis
Respiratory diseases	Chronic obstructive pulmonary disease (COPD), interstitial pulmonary disease/fibrosis, Asthma requiring hospital admission within the last year
Heart failure	Current
Malignancy	Active
Immunodeficiency	on steroids, immunosuppressants, Human Immune Deficiency (HIV)

Table 3
A summary of daily home isolation monitoring of COVID-19 positive cases by the home isolation team.

	Activities
Day 1	• The patient is given all home isolation instructions including duration of home isolation • The patient signs the home isolation obligation form (within 8 h) • The patient registers in Tatamman (within 8 h) • The patient registers in Tawakalna (within 8 h) • The patient is provided with necessary contact numbers to ring if any concerns or symptoms
Days 2 to 9	• Patient is contacted on daily basis to ensure patient remains asymptomatic/mild symptoms suitable for home isolation • No change in home environment suitability • Patient completes Tatamman self-assessment form • Patients' family negative family members remain asymptomatic • Patient condition is updated in Takkasi portal and in the electronic medical record (Epic) on daily basis
Day 10	• Patient is considered cured if remains asymptomatic • Patient is given necessary clearance and discharged from the service • Patient file is updated/closed in Takassi portal.

Statistical analysis was performed using JASP (an open-source project supported by the University of Amsterdam). We utilized descriptive analysis for demographics and patients' clinical characteristics and these were expressed as frequencies and percentages for categorical data and mean and standard deviation (SD). Comparison of asymptomatic and mildly symptomatic disease was done using chi square ($\chi 2$) test or Fisher exact test as appropriate for categorical outcomes. Significant factors were then entered into a logistic regression analysis to determine significance. The Odds Ratio (OR) and 95% confidence intervals (95% CI) were presented. A Boxplot of the age was presented as a comparison between different groups (asymptomatic vs. symptomatic, and those who were admitted or continued in home monitoring program). A P value ≤ 0.05 was considered significant. The study was approved by the IRB of the Johns Hopkins Aramco Healthcare (IRB # 20-43).

3. Results

During the study period from June 8 to October 18, 2020, there was a total of 5368 COVID-19 positive cases who were referred to the home isolation/monitoring program. The mean age (±SD) was 37.7 ± 19.4 years and 2397 (45%) were female and 2971 (55%) were male. The distribution (percentage) of cases in reference to age group is shown in Fig. 1. The majority of cases were between 21 and 60 years of age with 20% being 31-40 years and 17% being 20-31 years of age. Of the total cases, 295 (5%) required hospital admission, 45 (1%) were admitted to zone 2, and the majority 5028 (94%) continued home monitoring till clearance of infection. The mean age and SD of those who required hospital admission was 56.2 + 15.8 days and was more than those who were discharged (36.7 + 19.1) or cared for in zone 2 (33.6 + 15.5) (figure 2) (P value < 0.001) (Fig. 2).

Of the total cases, 3137 (59%) were asymptomatic and the remaining 41% were symptomatic. A comparison between these two groups is shown in Table 4. Asymptomatic patients tend to be younger with mean age (±SD) of 31.5 (18.6) and 46.45 (17.1), respectively (P < 0.001) (Fig. 3). In addition, there were significant differences between asymptomatic and symptomatic patients in relation to gender, being healthcare workers, and presence of significant medical conditions (Table 4). However, a logistic regression analysis showed that only age and presence of diabetes mellitus were associated with the presence of symptoms (Table 5).

4. Discussion

With increasing demands on healthcare system, different countries had adopted different strategies to deal with increasing number of COVID-19 cases. These strategies included deferring certain procedures and elective surgeries [9,10]. Since asymptomatic COVID-19 patients could transmit SARS-CoV-2, this had resulted in mandating social distancing, universal masking, and hand hygiene [11,12]. The initial cases in Saudi Arabia were followed by lockdowns of affected areas [3], the mandates that all positive cases to be admitted to the hospitals and that returning travelers were quarantined in designated hotels [4,6]. Subsequently, COVID-19 patients were required to be in a facility if they had been asymptomatic or had mild symptoms. This was then changed to home isolation monitoring. Here, we studied the outcome and epidemiology of patients with COVID-19 who were monitored at home.

Our data showed that of the total 5368 COVID-19 patients, 5% required hospital admission and 1% were admitted to zone 2. In another study looking at the rate of hospitalization after discharge showed 7.6% were readmitted [13]. However, these two studies are not comparable. In a smaller study of 173 patients who were monitored remotely, only 3 (1.9%) required hospitalization [14]. There are multiple advantages for home-monitoring program. It avoids the need for hospitalization and thus decreases the burden on the healthcare system and preserves hospital beds for the most severe cases. In addition, the program brings peace of mind and may alleviate the mental impact of isolation during this pandemic.

Of all the included patients, 5% required hospital admission. In a previous study of remote monitoring, 13 (0.35%) of 3701 symptomatic COVID-19 patients were admitted [15]. In another study, 2–3% of COVID-19 patients required readmission [16]. The requirement for zone 2 (less intense designated isolation facilities) was needed in 1% of the patients. The use of community dormitory-like medical facilities was tried in South Korea for those with mild symptoms [17].

The average days of home monitoring program was 10 days and in a community management of COVID-19, the length of stay was 8 days in a study from Australia [14]. In another study of 83 patients, the mean days of monitoring patients at home after discharge from emergency room was 21.8 days with an average of 14.5 daily survey responses [18]. In this study, we used the presence of comorbidities as indicator for admission at the discretion of the home monitoring team. In a previous study, a numeric prediction tool was used to screen COVID-19 patients who were cared for at home and showed higher admission rate among high-risk group of 23% vs. 1% in the lower risk group [19]. The use of an intermediate (zone 2) isolation program was ideal to decompress the hospital and provide better care than home when the latter is not suitable. The idea of using an intermediate zone was also tried to isolate and quarantine homeless individuals as well during the COVID-19 pandemic [20] especially that COVID-19 had resulted in disparity among rural and urban patients [7,8].

COVID-19 has a spectrum of presentations from asymptomatic cases

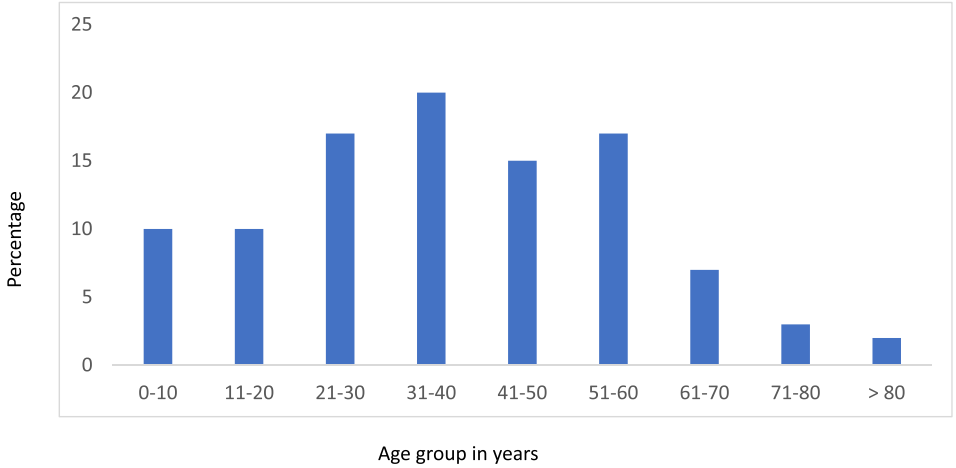

Fig. 1. The percentage of cases in reference to age group (N = 5368).

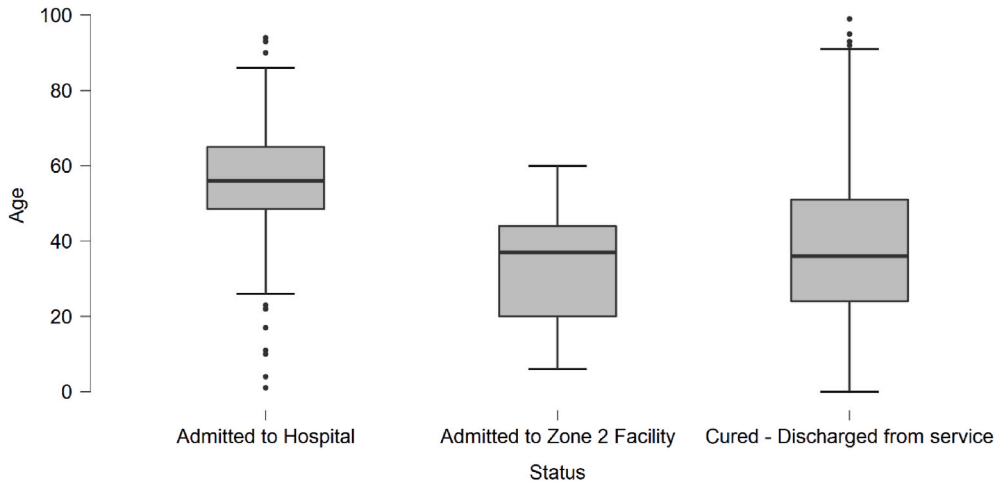

Fig. 2. A Boxplot of the age of patients who required hospital admission, admission to zone 2 facility and those who remained in the home monitoring program till recovery.

Table 4
A comparison between asymptomatic and symptomatic COVID-19 patients cared for as part of the home monitoring program (Data presented are number (%) except for the Mean days of home monitoring program (± SD)

	Asymptomatic N= 3147	Symptomatic N= 2221	P value
	Number (%)	Number (%)	
Female	1368 (43.5)	1029 (46.3)	0.038
Saudi	2810 (89.3)	1900 (85.5)	< 0.001
Health Care Worker	148 (4.7)	150 (6.7)	0.001
Significant Past medical history	219 (6.9)	1239 (55.7)	< 0.001
Cardiovascular disease	21 (0.67)	522 (23.5)	< 0.001
Diabetes Mellitus	12 (0.38)	777 (34.9)	< 0.001
Asthma	42 (1.3)	127 (5.7)	< 0.001
Hospital Admission	29 (1)	266 (12)	< 0.001
Zone 2 Facility Admission	0 (0)	45 (2)	< 0.001
Home Isolation	3118 (99)	1910 (86)	< 0.001
	Mean and (Standard Deviation)	Mean and (Standard Deviation)	
Age in years	31.5 (18.6)	46.45 (17.1)	< 0.001
Days of home monitoring program*	10.25 (1.37)	10.21 (1.34)	0.337

* Data based on 3118 asymptomatic and 1910 symptomatic who stayed in the home monitoring program throughout their illnesses

to severe disease requiring intensive care unit admission [6,21–23]. The current study showed that 59% of the patients included in the home monitoring program were asymptomatic. In KSA, all SARS-COV-2 positive patients were initially required by the Saudi Ministry of Health to be hospitalized including asymptomatic [4]. However, giving the increased demand on healthcare, asymptomatic patients could be safely managed at home. At the beginning of the pandemic, the exact percentage of asymptomatic disease was not known [21,24]. In a previous study from KSA, 54% of 82 admitted COVID-19 patients were asymptomatic [6]. It had been shown that the prevalence of asymptomatic COVID-19 patients was related to the testing strategy and the population being tested. For example, 50% of patients in the ship cruise and nursing facilities [25–29] and only 7.9% of the 500 patients were asymptomatic

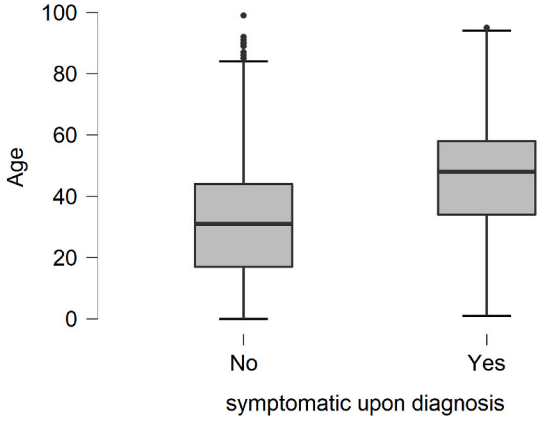

Fig. 3. A Boxplot of the age of patients who were asymptomatic or symptomatic upon diagnosis.

Table 5
a logistic regression analysis of associated factors with symptomatic COVID-19 patients

Parameters	Odds Ratio	95% Confidence interval		p
		Lower bound	Upper bound	
Age	1.075	0.054	0.09	< .001
Health care workers (Yes versus No)	0.786	-0.949	0.468	0.506
Cardiovascular disease (Yes versus No)	2.46	-0.07	1.87	0.069
Diabetes (Yes versus No)	12.097	1.31	3.676	< .001
BMI* (Obese versus others)	1.37	-0.199	0.828	0.229
BMI* (Overweight versus others)	0.893	-0.594	0.368	0.645
Asthmatic/chronic respiratory disease (Yes versus No)	1.028	-0.804	0.859	0.948
Smoker (Yes versus No)	1.231	-0.33	0.745	0.449
Nationality (non-Saudi versus Saudi)	1.114	-0.521	0.738	0.736

* Based on the WHO classification, "underweight" is defined as having a body mass index (BMI, kg/m2) below 18.5, "normal" corresponds to a BMI between 18.5 and 25, "overweight" corresponds to a BMI ≥ 25, and "obese" refers to those with a BMI ≥ 30

[30] and another study from Saudi Arabia showed that 9.3% were asymptomatic [31]. In a meta-analysis of 28 studies, asymptomatic SARS-CoV-2 infection was 1.4%–78.3% of 6071 COVID-19 cases [32]. In the current study, diabetes mellitus was significantly associated with the presence of symptoms. In a previous study, diabetes mellitus did not predict the presence or absence of symptoms in COVID-19 patients [33] and this is different from a study from KSA that showed diabetes mellitus to be more common among asymptomatic COVID-19 patients [6] and in a study from China [34].

Home monitoring service has been very well received and appreciated by both patients and other healthcare workers, hospitalists and Zone-2 quarantine facility staff. At the patient level the program is more suited for those patients who are low risk, especially when it comes to families with young children or elderly relatives. In these situations being quarantined in a facility can be very stressful and challenging. At the institutional level this service helped decreasing the load on the hospital and Zone-2 facility, and avoided the necessity for the opening of a second Zone-2 facility and the opening of a dedicated medical floor in the current Zone-2 quarantine facility.

In conclusion, the utilization of home monitoring program was effective and safe in patients with no symptomats or had mild symptoms and those who were low risk of complications. This service is of particualr importance as the pandemic grew and affected a substanial number of patients allowing capacity and resilience of the helathcare systems.

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Ethical approval

The study was approved by the Johns Hopkins Aramco Healthcare Institutional Review Board (IRB # 20-43).

Author statement

Jaffar A. Al-Tawfiq: conceptual design, data analysis, helped with the first draft of the manuscript.

Hatim Kheir: conceptual design, data collection and analysis, drafted the first manuscript.

Talal Al-Dakheel: data collection, helped with the first draft of the manuscript.

Saeed Al-Qahtani: conceptual design, helped with the first draft of the manuscript.

Hussain AlKhadra: data collection, helped with the first draft of the manuscript.

Ahlam Sarhan: data collection, helped with the first draft of the manuscript.

Maryam Bu Halaiga: data collection, helped with the first draft of the manuscript.

Rana Ibrahim: data collection, helped with the first draft of the manuscript.

All authors finalized and approved the final draft of the manuscript.

Declaration of competing interest

The authors declare no conflict of interest.

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