# COVIDCare: A Digital Solution for Follow-up of Individuals with Suspected or Diagnosed COVID-19

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## *Abstract*

**Background:** The coronavirus disease (COVID-19) pandemic has generated unprecedented and sustained health management challenges worldwide. Healthcare systems continue to struggle to support the needs of the majority of infected individuals that are either asymptomatic or have mild symptoms.

**Objective:** To rapidly and safely address gaps in the healthcare support available from initially, and repeatedly, overwhelmed providers and systems. We sought to create a digital healthcare solution that could appropriately monitor and manage needs of individuals requiring self-isolation due to suspected or diagnosed COVID-19 with mild to moderate symptoms.

**Methods:** A theoretically grounded multiplatform digital healthcare application was created to safely monitor and support this group of affected individuals based on rapidly emerging scientific guidance. The solution – COVIDCare – was designed to address this need and to be flexible enough to adapt to the evolving management requirements of various stakeholders to reduce COVID-19 infection rates, acute hospitalizations and mortality.

**Results:** The COVIDCare multiplatform solution provides a hybrid model of care that includes mobile and online platforms, paired with direct clinician input. The patient mobile application includes four program components: 1) symptom management, 2) patient education, 3) wellbeing support, and 4) communication with healthcare providers. The clinician web-based portal includes secure, bi-directional, chat communication between the patient and clinician.

**Conclusions:** COVIDCare can flexibly address strategic needs of strained healthcare systems and is customizable to meet the needs of employers and public health stakeholders who continue to manage the lasting impact of the COVID-19 pandemic.

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# Original Manuscript

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*Authors removed for blinded peer review*



Keywords: Coronavirus, Digital Health, Multiplatform, Chat, Symptom Tracking, Wellbeing

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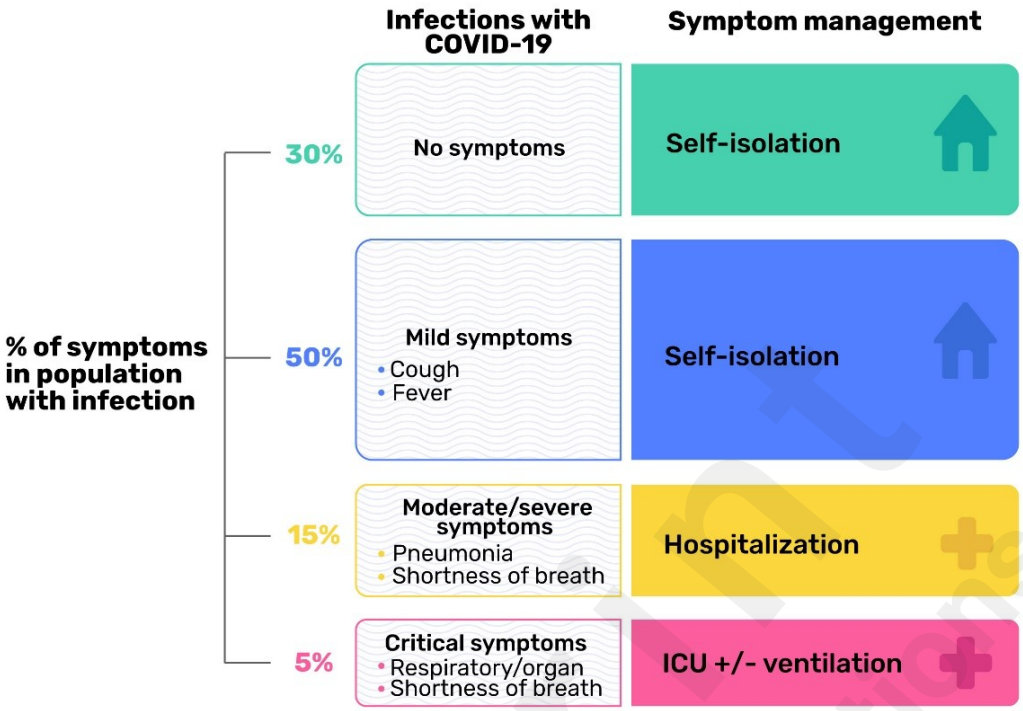
## Introduction

The COVID-19 pandemic uncovered several unprecedented challenges for healthcare systems worldwide. Research from different countries so far indicates that around 18-20% of individuals who are infected have moderate to severe symptoms and require medical management[1–4]. The remaining 80% of those infected are either asymptomatic or have mild symptoms. The management of this majority subgroup -- the 80% of individuals seeking medical care who were either suspected or diagnosed with no or mild symptoms related to the disease -- posed a challenge to public health management [5–8] and to stressed healthcare providers and systems [9–12]. Many symptomatic individuals impacted directly by COVID-19 were not hospitalized, in part due to allocation of limited hospital resources for only those with the most severe symptoms requiring hospitalization[1,9,13]. Healthcare resource allocation across acute and outpatient clinical care contexts clearly presented a significant challenge in the early phase of the pandemic and can continue to strain systems of care as infection rates fluctuate.

An effective public health response to limit the spread of the virus requires those who are suspected of having COVID-19 to be tested to confirm the diagnosis and to take appropriate next steps. The requirement for diagnostic testing, but inconsistent availability of testing resources, presents another layer of challenge especially in resource poor areas or in places where there are few diagnostic tests available. This resulted in large numbers of individuals who were suspected of exposure and could not receive timely testing and thus needed to quarantine from others. In addition, individuals who were positively diagnosed, but were either asymptomatic or experienced only mild to moderate symptoms, were advised to self-isolate at home with close and regular follow up to monitor for any changes in their symptoms.

*Figure 1: The burden of COVID-19 morbidity and mortality*




The infection rates among healthcare professionals rose in a magnitude similar to, or greater than, what occurred in the general public [9]. Important information characterizing morbidity among essential workers at risk for COVID-19, including those health care personnel most at risk for mortality, [14] is emerging and supports the need for continued surveillance and the development of strategies to protect essential workers and those they serve. Further underscoring this need was the imbalance between supply and demand for medical resources in many countries, which presented global questions about fair allocation of medical resources and personnel during the pandemic [1]. Factors serving to limit the supply of healthcare workers included adherence to public health standards that require an exposed healthcare worker to quarantine for 14-days. Emerging information about the risk of transmission from pre-symptomatic cases underscores a sustained need for vigilance, as pre-symptomatic individuals have an incubation period of 4-7 days before COVID-19 symptoms appear and can reportedly infect 1.4 to 6.5 individuals during that time [15]. Potential provider shortages continue to be of concern during periods of high infection levels and corresponding spikes in the number of hospitalizations due to positive COVID-19 diagnoses and related diseases [11].

Such provider shortages initially necessitated reactivation of retired healthcare workers and onboarding of new medical personnel. For example, many US states loosened their licensing rules to give those with clinical skills the ability to participate, such as allowing out-of-state physicians to practice and requesting retired physicians to volunteer [11]. The Governor of New York activated retired and student healthcare professionals from >52,000 volunteer health professionals, that included 2,400 nurse practitioners and 2,265 physicians [12]. The U.S. Department of Veteran Affairs recruited retired federal health care workers from social media. Internationally, the Taipei Centers for Disease Control and Prevention responded to the shortage by implementing an ongoing program to recruit and train general practitioners, retired medical professionals and school nurses [10].

Rising rates of the disease and corresponding increases in the workload of healthcare workers resulted in widespread burn out related to the escalating number of hours physicians were working without breaks [16]. In addition to treating patients in the hospital, clinicians were required to follow up on patients who were at home [7]. During this time, mental health of healthcare workers due to the effects of acute and chronic stress were of major concern [14,17]. In the absence of a well-organized strategy to sustain the healthcare work force, scientists and clinicians called for a shift to a longer-term and sustainable solution [18].

In addition, the uncertainty of the COVID-19 disease progression rapidly changed the landscape of the pandemic in several countries. For example, in Italy, where the burden of mortality was for a period relatively greater than other countries, healthcare professionals perceived the response to COVID-19 as a continuously evolving process with no visible end point. In many medical settings, adapting to changes were required by the hour [19]. The psychological toll of chronic uncertainty [14] and countless other factors led to a demand for a flexible solution for disease surveillance and follow up that could be used by workplaces and by healthcare professionals, as well as available for use by the general public.

The novel health care challenges emerging from the COVID-19 pandemic demand new

health care models and patient care management modalities, with digital health strategies holding great potential for delivering solutions [20]. A recently published scoping review [21] suggests that most initial digital health solutions were oriented to surveillance and symptom tracking. There were many popular digital applications existing at the initial onset of the pandemic available to alleviate the impact of the pandemic for the general public. These applications could conceivably support resilience through meditation or counseling, as well as some telemedicine applications available to support socially distanced care access from a healthcare provider. However, there were no comprehensive digital healthcare pandemic control strategies that could address the needs of the overwhelming majority of individuals impacted by COVID-19. A solution that could effectively support and follow up on individuals who required self-isolation due to suspected or diagnosed COVID-19 with mild to moderate symptoms was needed.

## Methods

The key to a successful strategy for pandemic preparedness and response is a well-planned, effectively communicated and coordinated emergency response that draws on medical mobilization. Our solution – COVIDCare -- is a multiplatform digital healthcare application for healthcare providers to effectively and safely monitor individuals who are not receiving acute care in a hospital setting. The overall objective for COVIDCare was to create a solution that could support social distancing guidelines intended to reduce COVID-19 infection rates, acute hospitalizations and mortality. The implementation of our solution may be administered by actively practicing, retired, or new medical professionals. It presents minimal risk of infection for healthcare providers, which may in turn alleviate stress and prevent further burn out. Additionally, the flexibility of this digital platform readily allows for changes to be incorporated, in order to adapt to needs that may develop as the pandemic progresses. The COVIDCare solution is a comprehensive digital health management system that allows close safety monitoring and deploys an escalation protocol if the patient's symptoms require acute management in the hospital setting. This digital solution can also be further customized to meet the specific needs of a particular target population or treatment context.

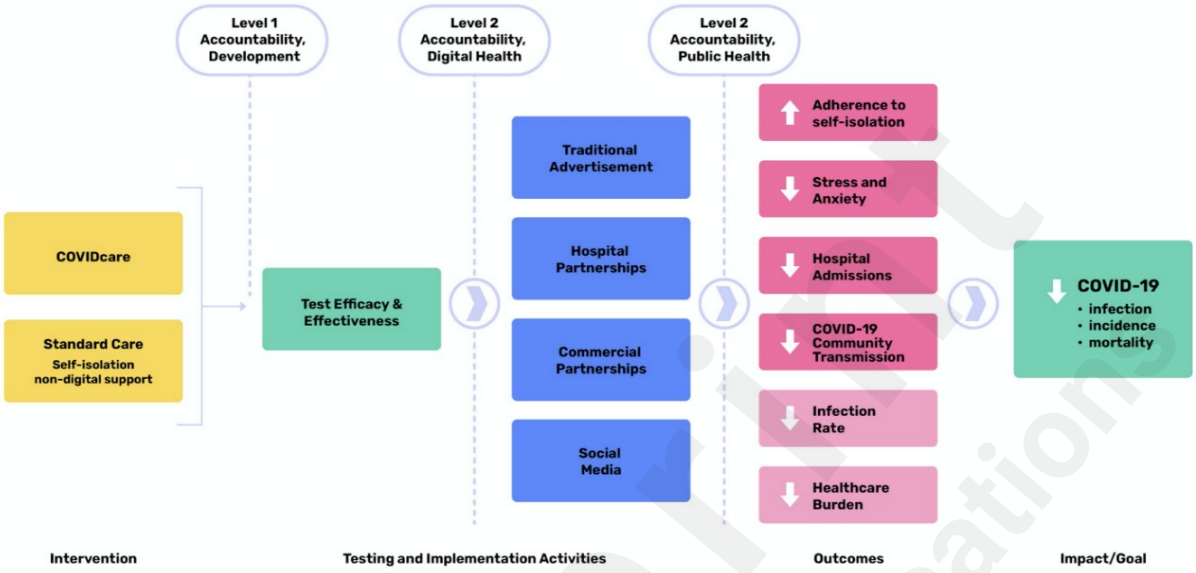
Theory of change methodology provided the foundation for the development of COVIDCare

and its efficacy. It proposes that the underlying rationale for high rates of COVID-19 infection in Americans is due to a late initial response, less stringent social distancing, lack of diagnostic resources, and stressed healthcare systems. Thus, our theory of change (*Figure 2*) proposes that to reduce the incidence of COVID-19, we must provide digital interventions that help manage self-isolating individuals with their symptoms, medications, mental health, communication with their clinician, physical activity, quality of life, and understanding to effectively self-manage their symptoms. An accountability ceiling is often drawn in a theory of change between the impact and the long-term outcome. All outcomes below a given accountability ceiling represent changes or activities that stakeholders hold themselves accountable for, including results of an intervention they expect to achieve[22].

We define three levels of accountability ceilings to indicate that three separate accountability parameters exist to develop, test and implement a digital healthcare intervention through the proposed model depicted in Figure 2. COVIDCare is presently at the first level, where scientists, developers, computer engineers and user experience researchers have planned, designed, and developed the digital healthcare product, with the level 1 accountability ceiling denoting the end of development. The next step includes digital health epidemiologists, methodologists and clinical scientists conducting intervention testing and implementation activities to determine efficacy and effectiveness. The level 2 accountability ceiling for the COVIDCare digital health solution pictured in Figure 2 identifies the point to be reached at the end of testing. Once effectiveness is established, broad implementation of the digital health intervention in different environments such as communities, universities, housing developments, and social media etc., will be performed by implementation and improvement scientists to achieve a level 2 accountability ceiling for public health. The widespread implementation and adoption of the intervention is proposed to improve adherence to self-isolation and reduce stress and anxiety during the isolation period. These patient outcomes will subsequently lead to favorable distal outcomes including low incidence rate, reduced community transmissibility, reduction in hospitalizations and deaths (by prevention of disease progression from mild-moderate to severe symptoms due to better care by patients), seamless

follow-up by clinicians, reduced healthcare burden, and ultimately reduce the impact of COVID-19 (infection, incidence, and mortality).

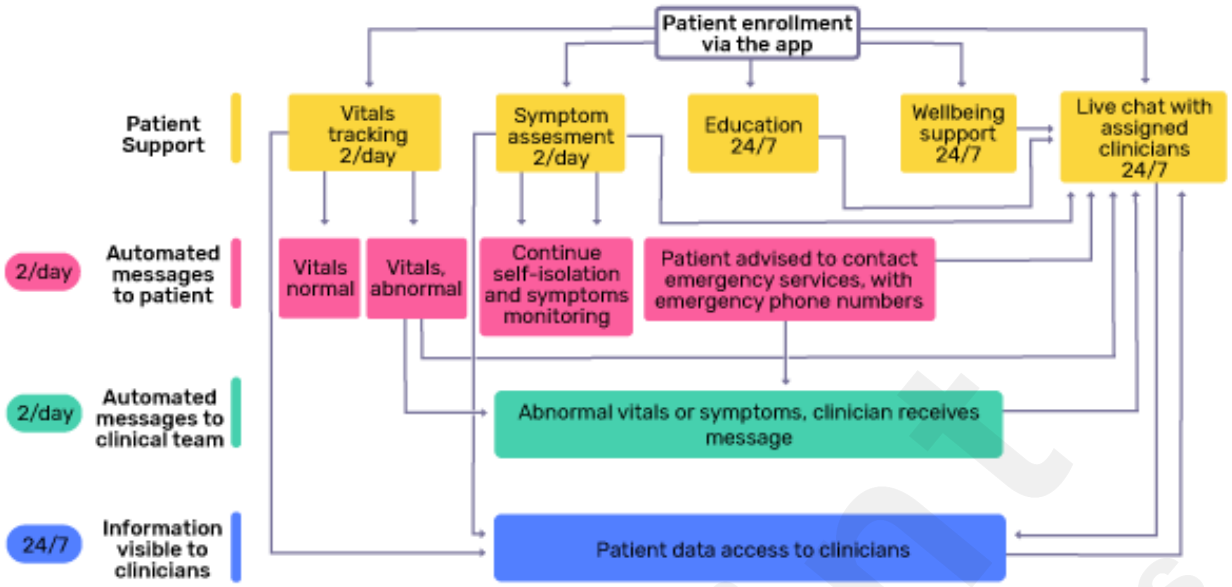
*Figure 2: Theory of change for digital surveillance and follow-up*




## Results

COVIDCare is a recently developed multiplatform digital solution created to connect the individual, who is either asymptomatic with a positive diagnosis or test positive with mild-to-moderate symptoms (referred to as a patient), and their treating clinician. This digital ecosystem was designed for a web-based interface and components were also created for mobile platforms (iOS and Android). The patient can interact with the mobile application on his/her smartphone and also interact with a clinician (a healthcare coach) and/or healthcare provider (HCP) through a responsive website to facilitate monitoring multiple patients. Figure 3 depicts the components of the COVIDCare treatment plan and their frequency of access after the point of enrollment.

*Figure 3. Components of COVIDCare*



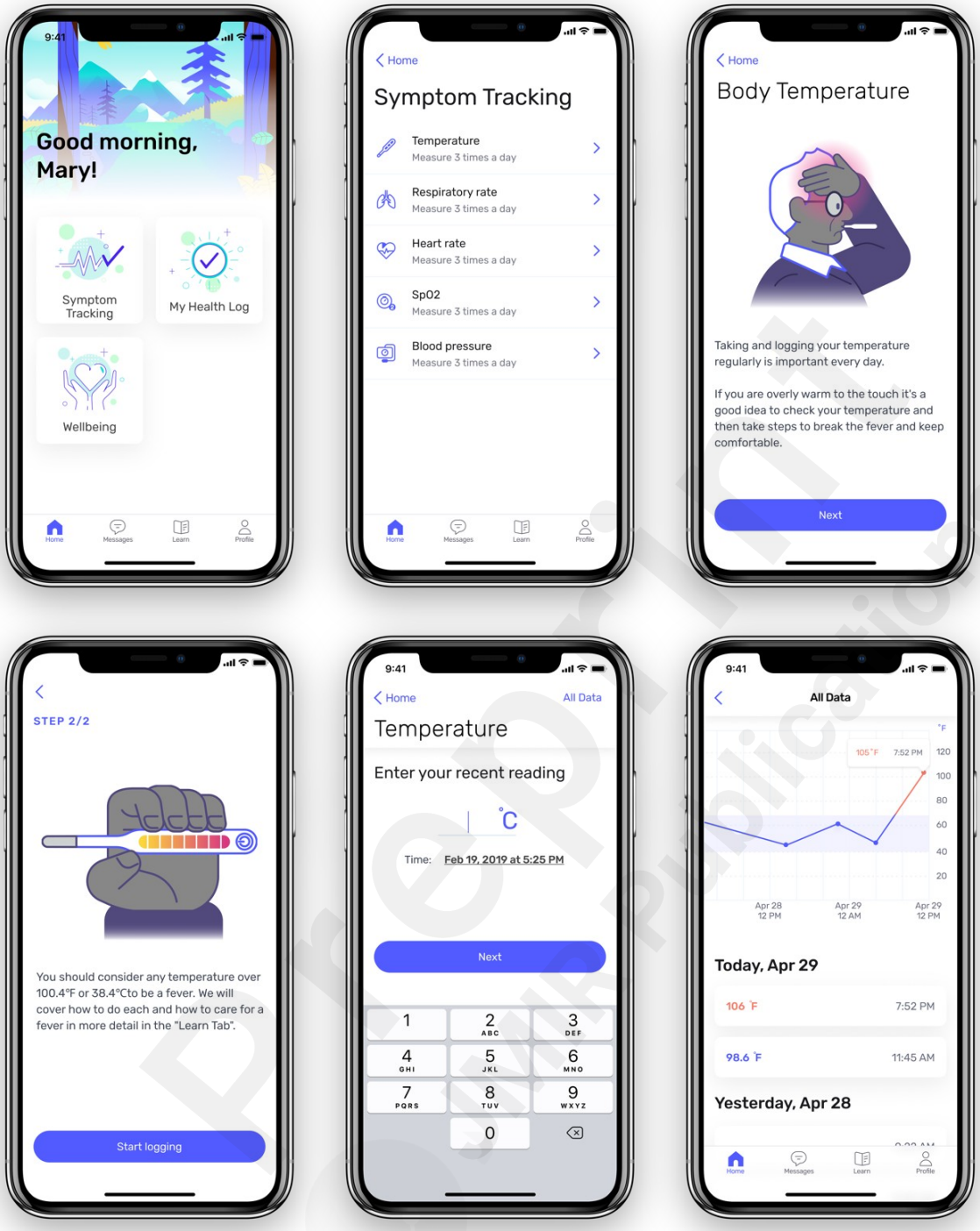

*Enrollment.* Patient enrollment should be based on shared decision making between a patient and their HCP. Service starts after a patient consents to the terms of use and subsequently enrolls in COVIDCare. If the patient has an active caregiver in their home setting, the caregiver can also have a separate access, with a unique digital login that connects them to the patient's digital information. Patient and caregiver demographic information, along with relevant patient medical history and baseline health-related data, will be collected upon enrollment. The HCP access will include all patient information provided at baseline, including a medical history, and all health-related data entered into the mobile app by the patient over the course of the care plan.

*The Mobile Application.* The COVIDCare mobile application available to the patient contains four program components: 1) symptom management, 2) patient education, 3) wellbeing support, and 4) communication with their healthcare provider. Our digital ecosystem is designed to support both patients and clinicians. Patients are engaged with educational content and wellbeing support. Clinicians are kept informed with real time vital signs and symptom tracking which allows timely intervention and management described in more detail below.

*Symptom management.* Symptom management has two main components, vital signs tracking and daily heath check. The vital sign tracking component requires recording of respiratory rate, temperature, heart rate, blood pressure and oxygen saturation twice per day. Short and simple

instructional videos are available for self-measurement (Figure 4). Blood pressure and oxygen saturation are measured if the patient has suitable devices available to collect this data. The recorded values are tracked over time and graphically visible to patients. If a vital sign is out of the appropriate physiological range, this feedback is indicated to the patient and an assigned clinician (healthcare coach or a referring provider) is automatically alerted, who will then contact the patient by chat or phone. At any time, the patient is able to initiate a chat conversation with the assigned clinician.

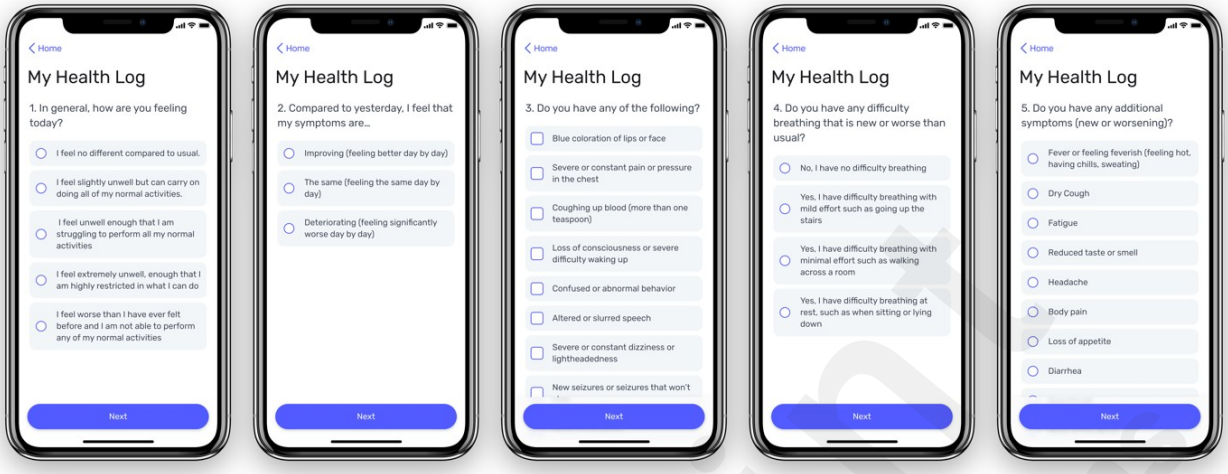
*Figure 4. Symptom Tracking*




The Daily health check is self-assessment of COVID-19 symptoms with the aim of determining the severity of the symptoms and the need for emergency medical support. The assessment consists of a short survey of conditional branching multiple-choice questions (Figure 5). Questions are based on the guidelines by National Health Services, Centers for Disease Control and Prevention (CDC) and the World Health Organization (WHO) guidelines on identification of

respiratory distress as a result of COVID-19 infection [5–7,23].

*Figure 5. Daily health check*



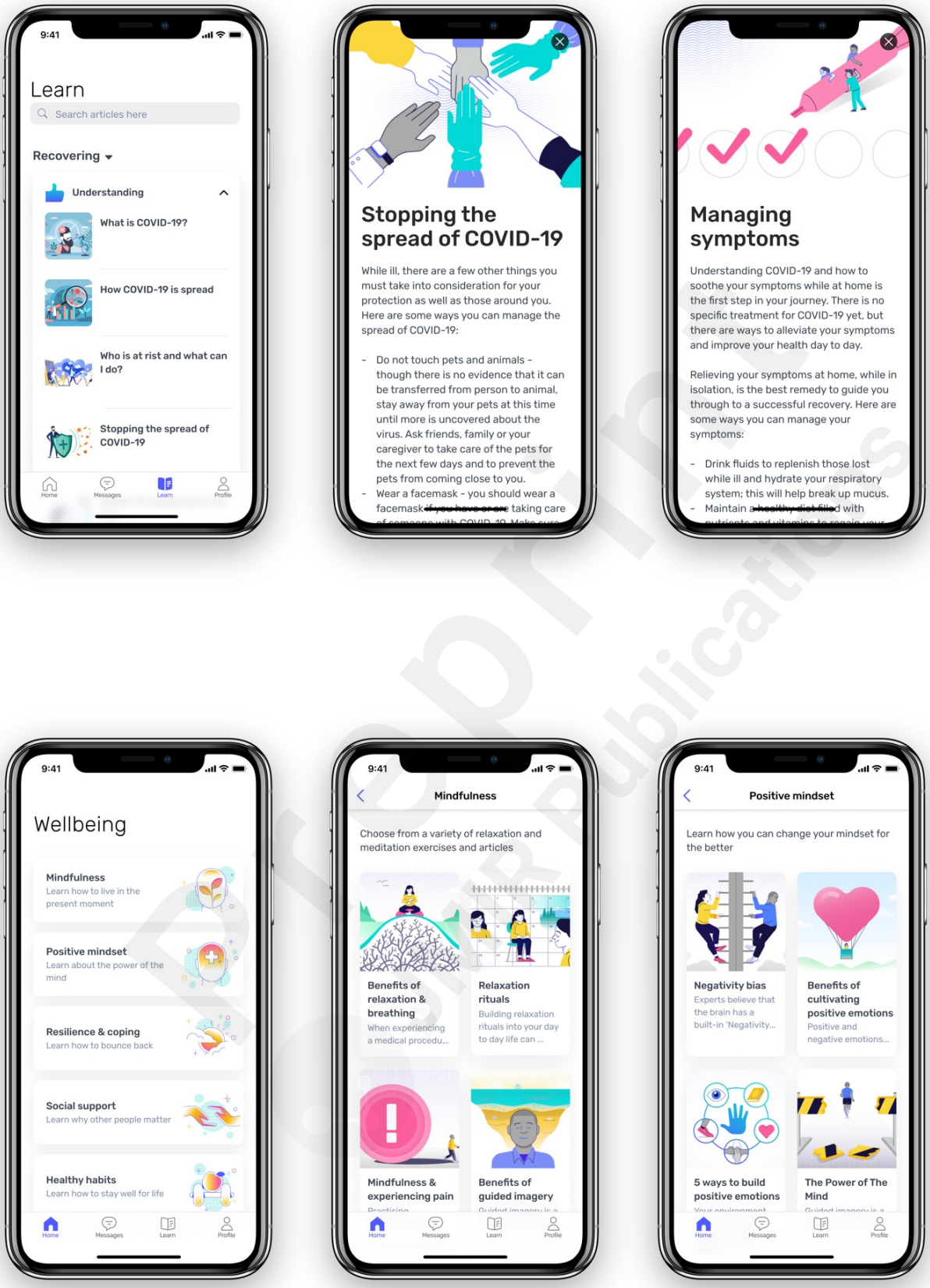

The flow of the questions branches according to each response. Based on responses, the patient is recommended to either continue to monitor symptoms or to contact emergency services. All recorded answers to the survey are sent to the assigned clinician who receives an automated message of the survey results. The assigned clinician may then contact patient with the appropriate recommendations and/or medical advice. The home page of the application has a link to local and national medical emergency contact numbers, which also facilitates the patient's access to emergency healthcare services. The patient may also initiate a chat with the assigned clinician, who also has access to the patient responses given. The daily health check is initiated once in 12 hrs. The patients are also provided with a temporal view of their symptoms in a symptom tracker.

*Patient education.* A comprehensive library of educational content is also provided for patients to access (Figure 6) to inform themselves about COVID-19 symptoms, manage symptoms, and to support overall wellbeing. The content is specific, short, and engaging and is provided through aural and visual media to cover three topics: 1) facts regarding COVID-19, 2) isolation management, and 3) wellbeing support. The educational content is written at a 6th grade reading level. The content on the facts related to COVID-19 and management of isolation was created based on guidance from WHO, CDC and the NHS [6,7,23]. The wellbeing support section is anchored around three main areas: Positive thinking, Positive action and Positive interaction, and

was created by an experienced digital health wellbeing expert.

*Wellbeing support.* This section consists of content that includes evidence-based stress reduction strategies, mindfulness and relaxation exercises which have proven effective in reducing patient stress levels [24–26]. Exercises like “box breathing”, which is a type of breathing exercise that requires the patient to visualize breathing around a box, is practiced by Navy seals and has been shown to help them deal with highly stressful events. It has been proven to be very effective in reducing stress and anxiety [27]. Similar breathing exercises that we have included in the app that focus on diaphragmatic breathing have been proven to reduce stress levels and calm the nervous system and mind [28]. They can be accessed easily, and their benefits include reducing the amount of adrenaline and cortisol in the body, which many COVID patients experience, and have long term benefits when dealing with stress and anxiety [29]. Even during extreme stress, exercises focused on breathing and relaxation can alleviate negative thoughts, moods, and feelings, and increase rates of recovery [30]. These relaxation exercises are presented through text, image and video formats (Figure 6). Self-management strategies include breathing and progressive muscle relation exercises, guided visualization, and a loving-kindness themed meditation, all of which support improved mental wellbeing [31,32].

*Figure 6. Patient educational & wellbeing support content*




*Communication.* Secure, bi-directional, chat communication between the patient and clinician may be initiated 24/7 through the app by the patient (Figure 7) or initiated through a web-

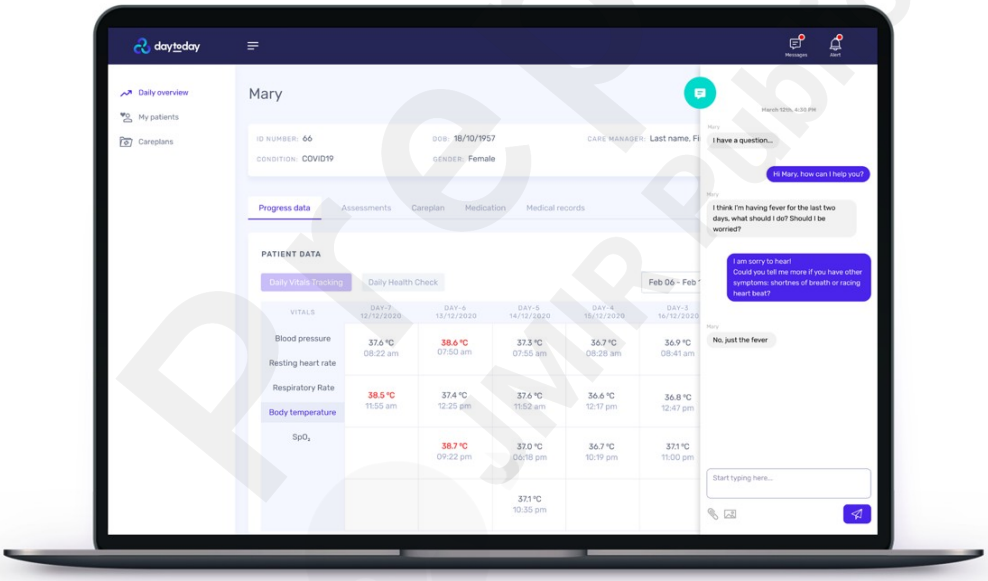
based portal by the clinician (Figure 8). The clinician response team may be designated by a hospital or a single clinician, as per details of the partnership.

Once a patient initiates chat communication functionality, the assigned clinician will receive a message and is expected to respond within a pre-determined duration. The preference and expectation for clinician response for the COVIDCare solution is for the quickest response time possible, similar to expectations set for a hospital emergency department. The clinician may assess the patient data and all data input from the patient's app-based interface in order to provide an appropriate response to the patient's query. The clinician can also send a direct message through the web-based interface to the patient which will appear on the patient's app interface on their smartphone. In addition, the communication feature also supports sharing images, documents and links, as needed.

The patient will also receive daily notifications, in the form of push notifications, that are designed to appear on the home screen of the smartphone consistent with information previously presented in Figure 3 depicting the components of COVIDCare. For example, "Check-in to COVIDCare" appears once daily in the afternoon, "Record your vitals" appears twice daily in the morning and evening, and "Conduct daily health check" appears twice daily in the morning and evening. Reminder messages are yet another form of communication which can be displayed on the banner of the home screen (e.g., encouraging use of wellbeing strategies and suggestions).

*Figure 7. Communication via the patient's smartphone application-based interface*


*Figure 8. Communication via the web-based clinician interface*




## Discussion

This project presents the developmental process and resulting components of COVIDCare, a multiplatform digital healthcare solution that connects patients to clinicians for continued follow-up of individuals with asymptomatic, mild and moderate diagnosis of COVID-19 (and those who are self-isolating at home) to safely manage and prevent disease progression and mortality. COVIDCare is concordant with the third domain of 2017 CDC's Pandemic Influenza 7-goal plan [8]. Domain 3 of this plan specifies medical counter measures to increase access and use of critical counter measures for response activities. Recently emerging literature speaks to the future of pandemic management and how valuable mHealth systems and platforms that can facilitate access to mobile care providers through telehealth will continue to be for situations requiring self-isolation [21].

To our knowledge, at the time the creation of the COVIDCare digital solution it was the first of its kind and notably distinct from digital solutions that were mainly intended to support contact tracing and symptom monitoring for self-use by individuals, without any input from clinicians [21]. The involvement of clinicians and close monitoring of symptoms is critical for individuals with asymptomatic, mild and moderate disease, with respect to the potential for the sudden emergence of severe symptoms and unexpected deterioration [33], and limited understanding of the natural history of COVID-19 disease sequelae. COVID-19 associated acute (and potentially chronic/persistent) health management needs, along with continued adherence to recommended social distancing practices more generally, support the lasting value of the COVIDCare digital solution into the future. While additional research is needed to test the efficacy of COVIDCare, this digital solution and the theory of change that supported its development holds great promise. It provides a hybrid model of care that includes mobile and online platforms, paired with direct clinician input, and further aligns with a need to support both the physical and mental wellbeing needs of an impacted patient [34]. Furthermore, the adaptability of the COVIDCare digital solution can not only reduce the significant patient-care burden experienced by healthcare professionals, but can also be customized to support the needs of an employer's management of employee symptoms or the public health needs of a government continuing to combat and effectively manage the impact of the lingering COVID-19 pandemic.

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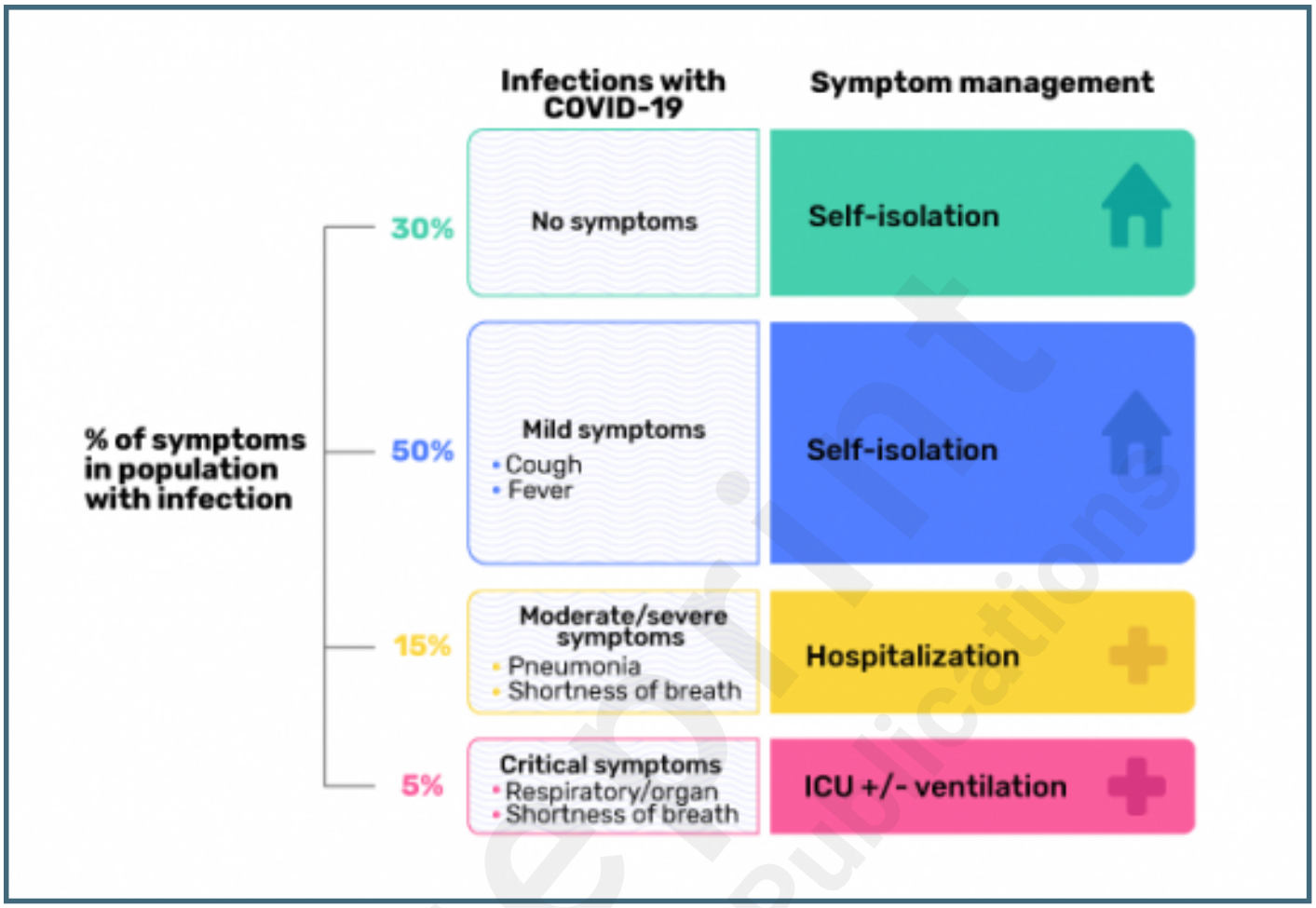
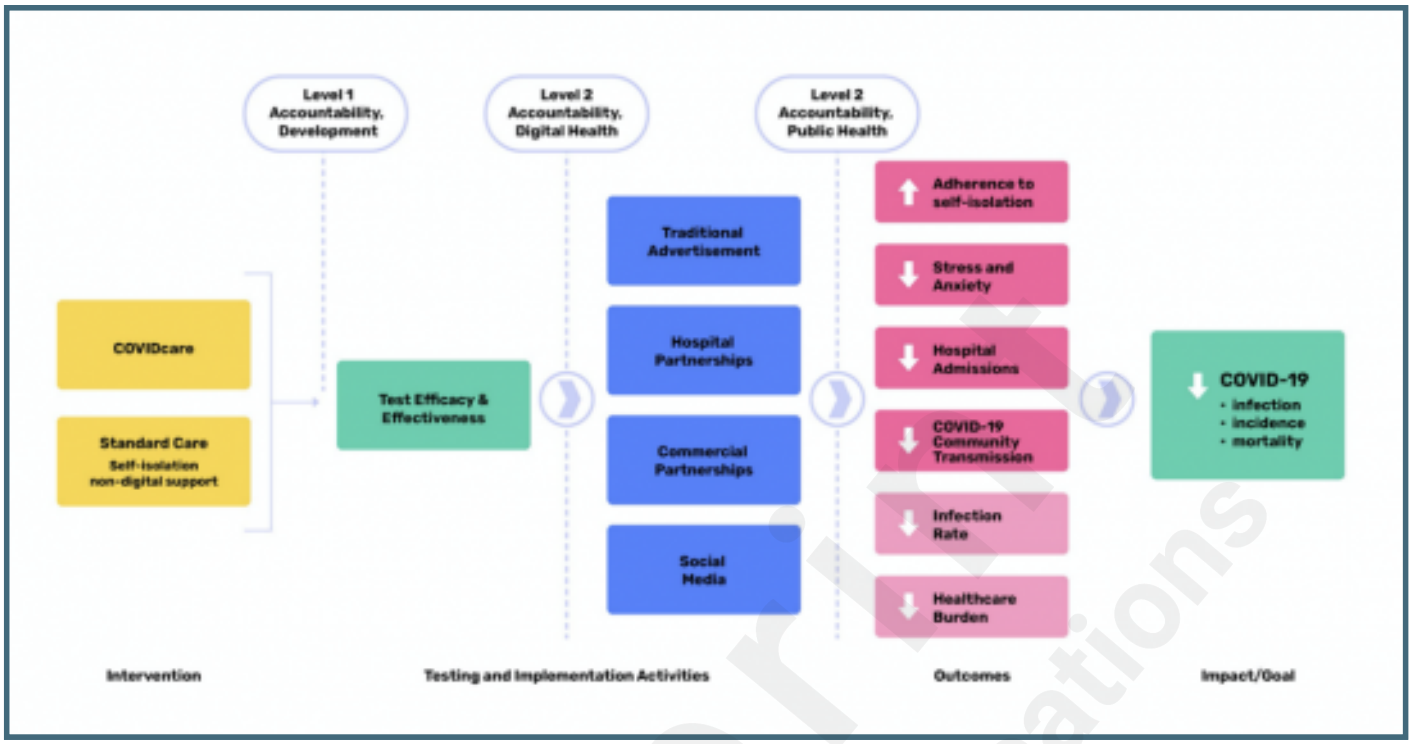
# Supplementary Files

# Figures

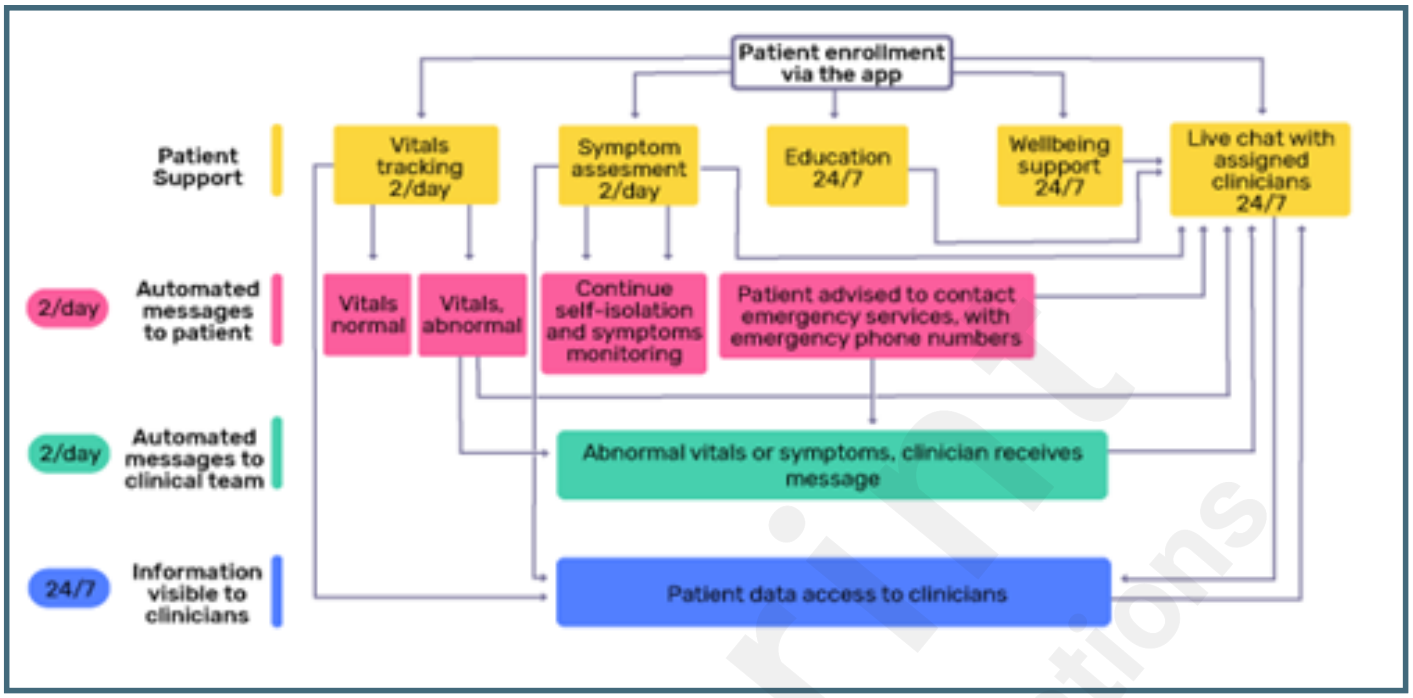
The burden of COVID-19 morbidity and mortality.



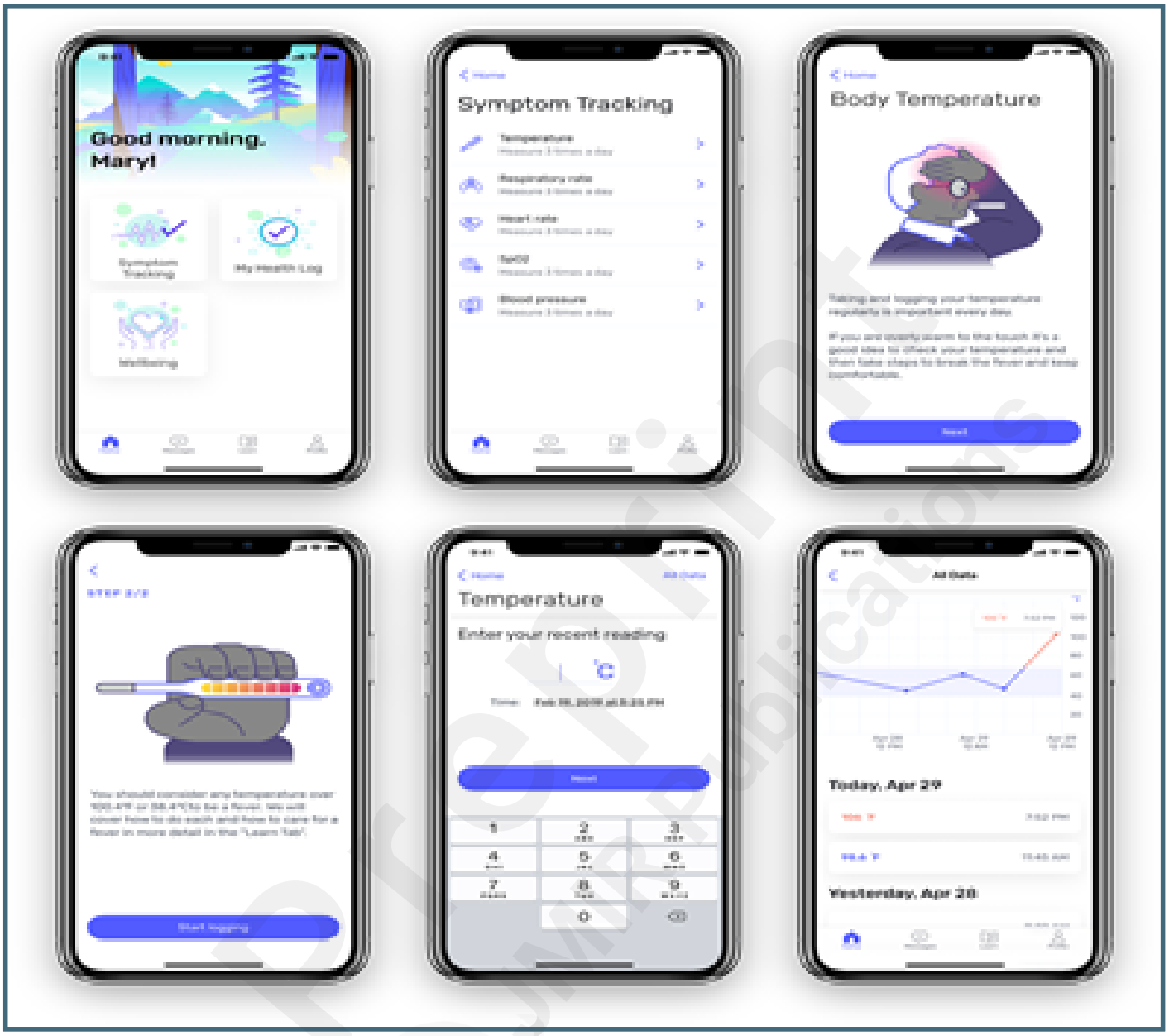
Theory of change for digital surveillance and follow-up.



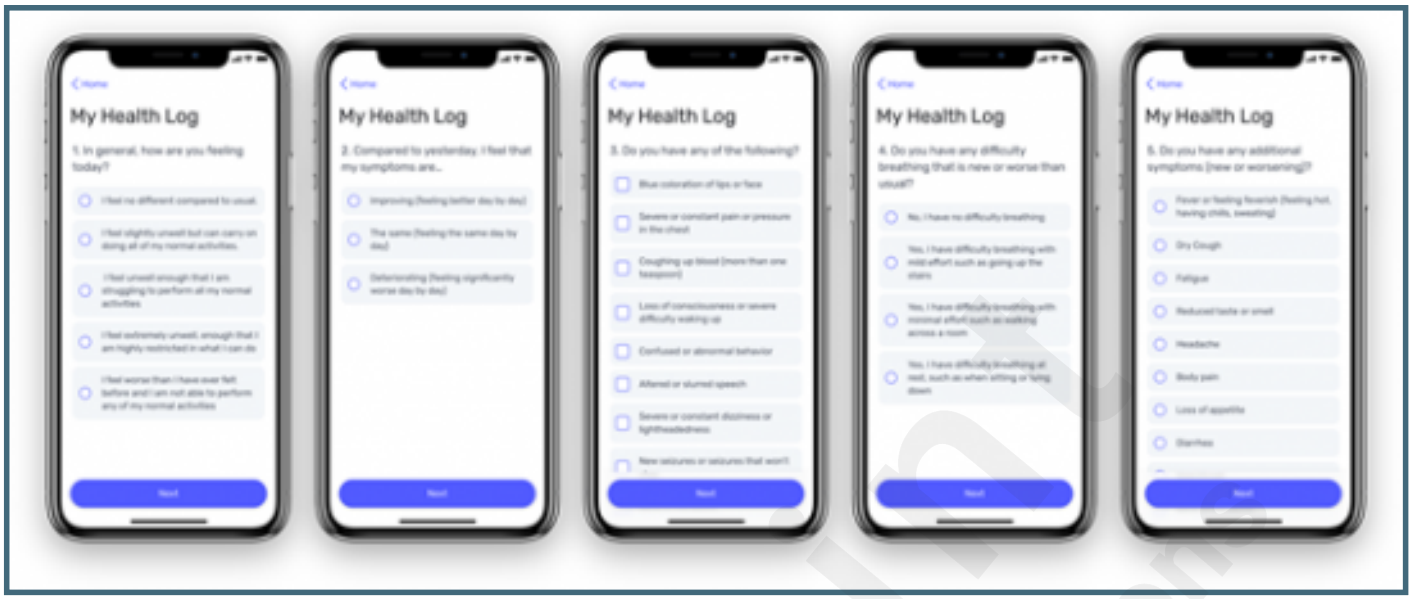
Components of COVIDCare.



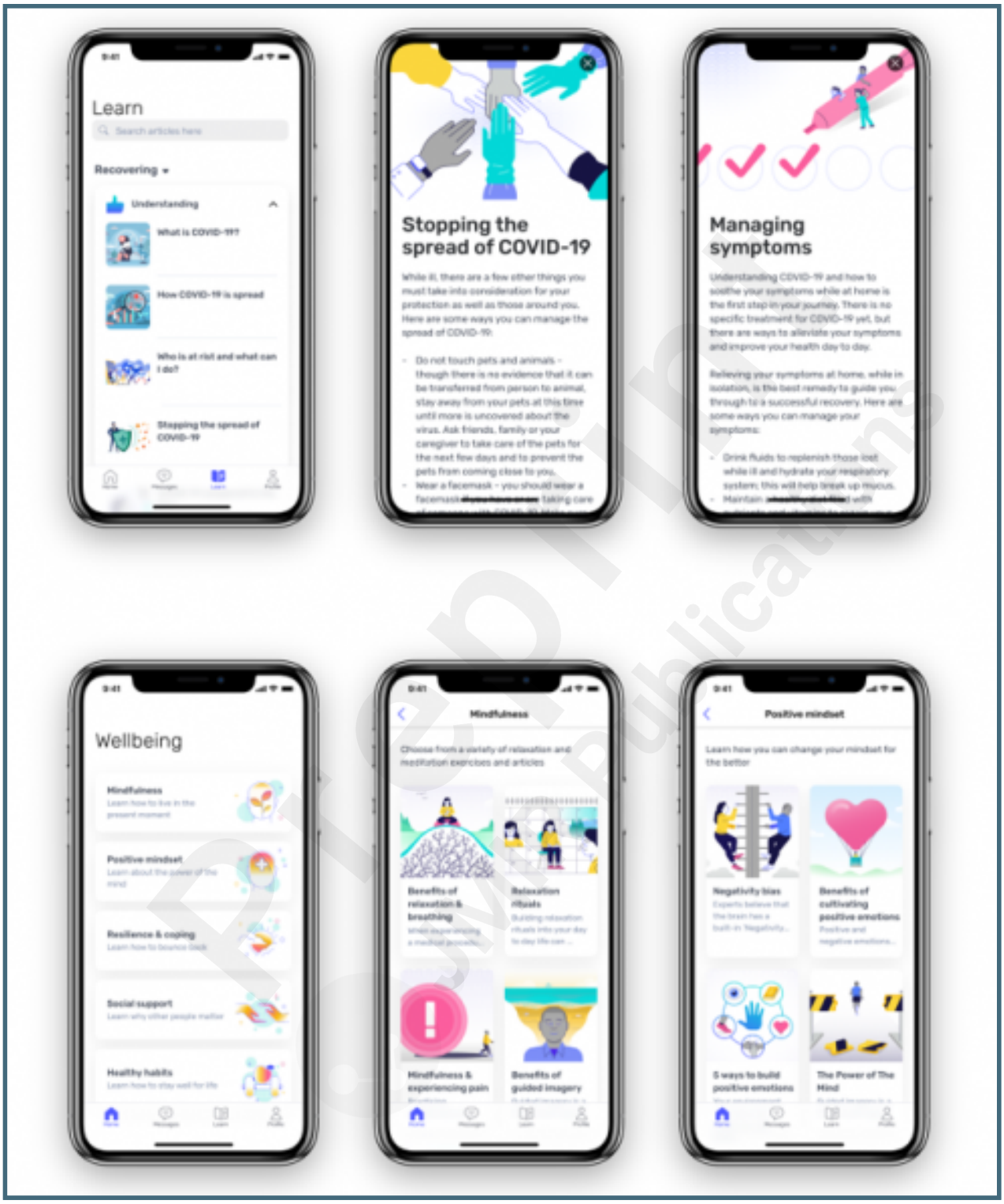
Symptom Tracking.



Daily health check.



Patient educational & wellbeing support content.



Communication via the patient’s smartphone application-based interface.

Communication via the web-based clinician interface.