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Curious thing, an artificial intelligence (AI)-based conversational agent for COVID-19 patient management

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ABSTRACT

There are no clear guidelines or validated models for artificial intelligence (AI)-based approaches in the monitoring of coronavirus disease 2019 (COVID-19) patients who were isolated in the community, in order to identify early deterioration of their health symptoms. Developed in partnership with Curious Thing (CT), a Sydney-based AI conversational technology, a new care robot technology was introduced in South Western Sydney (SWS) in September 2021 to manage the large numbers of low-to-medium risk patients with a COVID-19 diagnosis and who were isolating at home. The CT interface made contact with patients via their mobile phone, following a locally produced script to obtain information recording physical condition, wellness and support. The care robot has engaged over 6323 patients between 2 September to 14 December 2021. The AI-assisted phone calls effectively identified the patients requiring further support, saved clinician time by monitoring less ailing patients remotely, and enabled them to spend more time on critically ill patients, thus ensuring that service and supply resources could be directed to those at greatest need. Engagement strategies had ensured stakeholders support of this technology to meet clinical and welfare needs of the identified patient group. Feedback from both the patients and healthcare staff was positive and had informed the ongoing formulation of a more patient-centred model of virtual care.

Keywords: artificial intelligence, care robot, community health, conversational agent, COVID-19, model of care, patient-centred care, virtual care.

Introduction

As of August 2022, over 6.4 million people worldwide have died from the viral respiratory disease, SARS-CoV-2 (coronavirus disease-2019 (COVID-19)) and in Australia, nearly 2000 people died from COVID-19 in 2020–21 (Australian Institute of Health and Welfare 2021). Although Australia had relative success in containing the COVID-19 pandemic in 2020, this containment is threatened by the existence of new and more easily transmissible variants (Centers for Disease Control and Prevention 2021).

Many initiatives have been been accelerated as a result of the global COVID-19 pandemic, compelling a change to the way people lived, worked, played, and engaged (Anderson *et al.* 2021). These include the associated rise in technologies such as video conferencing, cloud contact solutions, knowledge management and more (Anderson *et al.* 2021).

Context – policy or service context

Health care is going through a rapid evolution to meet the uncharted demands of the COVID-19 pandemic (Swayamsiddha *et al.* 2021). The strategy of 'Hospital in The Home (HITH)' has been rolled out carefully in a number of locations within Australia and across the world (Rosen *et al.* 2010). Patients have benefited from being able to remain at home, eat their own food, have their own routine and comforts, and avoid any risk of

adverse events from hospital admission (Rosen *et al.* 2010). Treating lower-risk COVID-19 patients at home with daily monitoring calls from clinicians was initiated during the COVID-19 pandemic in 2020. Patients are engaged in a conversation regarding their condition, symptoms and general wellbeing. During these calls, escalations may occur where a patient is indicating increased illness, which can include the provision of an ambulance transfer to the nearest emergency department.

With the rise in the number of patients infected with COVID-19, combined with a surge in vaccinations, an increasing number of patients were suitable for HITH management. The significant increase in positive cases in July 2021 impacted the capacity to call every patient every day by an experienced clinician. Compounding this challenge was a broad socio-demographic patient base that was impacted by COVID-19. Consideration was given to alternate methods of optimising the patient check-in while not increasing risk.

Review of literature on similar cases

The growing capability of artificial intelligence (AI) and the high demand for healthcare services has led to the development of conversational agents designed to support a variety of health-related activities, which requires simplicity of use, capacity to scale up, options to escalate immediately to a human, be able to ask a series of questions, and require no equipment at the home of the patient (Milne-Ives *et al.* 2020; Tudor Car *et al.* 2020). In the last two decades, such AI-based conversational agents have demonstrated multiple benefits to support healthcare professionals for diagnosis, data collection, coaching, monitoring, education of patients and treatment support (Milne-Ives *et al.* 2020; Schachner *et al.* 2020; Tudor Car *et al.* 2020). Automation of these tasks reduces the burden on clinicians so they can focus on more complex work and increase the accessibility of healthcare services to those at greatest need (Milne-Ives *et al.* 2020). However, a study by Bian *et al.* (2020) reported that an AI-assisted follow-up system helps obtain more comprehensive feedback, but lacks depth and pertinence.

Artificial intelligence technologies and tools played a key role in every aspect of the COVID-19 crisis response, and has been extensively used for early warnings and alerts, tracking and prediction, diagnosis and prognosis, monitoring, severity assessment, treatments and cures, and social control (Gupta and Lall 2021; Swayamsiddha *et al.* 2021). Advances in AI has contributed to the decreased physical contact and mitigated the risk of disease transmission, reducing the need of frequent and unnecessary hospital visits by virtual monitoring of positive cases with mild symptoms, and also reduced the workload of healthcare workers (Scott and Coiera 2020; Swayamsiddha *et al.* 2021).

Limited evidence is available on the effectiveness and usability of AI-based conversational agents in health care (Milne-Ives *et al.* 2020; Schachner *et al.* 2020; Tudor Car *et al.* 2020; Geoghegan *et al.* 2021). No clear guidelines or validated models are available for the monitoring of COVID-19 patients in the community, in order to identify the deterioration in patient medical symptoms. An effective virtual health monitoring model of care that detects early deterioration and reduces the burden on hospital-based clinical care will improve patient outcomes, and ensure that service and supply resources can be directed to those at greatest need. This will benefit individual patients, primary and specialist care teams and acute care hospitals throughout Australia. For conversational agents to be successful in health care, it is crucial to understand their effectiveness in achieving their intended outcomes.

The case study or practice innovation

In this paper, we describe the approach in the development and implementation of the Curious Thing (CT) conversational agent to guide policy makers and healthcare professionals to meet clinical and welfare needs of the identified COVID-19 patients isolated at home.

What is curious thing?

The conversational AI platform from Australian deep technology company, Curious Thing (CT), was designed to be curious, engage in question- and-answer sessions and leverages machine learning to discover insight. It has the capability to generate context-relevant questions until it is satisfied and it has uncovered sufficient insight. This capability to ask open questions, allow patients to answer in their own words, and follow up with specific closed or clarification questions appeared to mirror the outcomes required from the calls being undertaken by humans. It could engage and ask a series of questions regarding the patient's symptoms and health, and ask deeper questions if required. Using AI to conduct a conversational follow up will provide patients with predictability around the questions, ensure consistency in questioning and in data capture. The CT's platform had proved the capacity to scale earlier in the year in the State of Victoria, where up to 200 000 conversational AI calls per day were placed to small businesses to assist and ensure COVID-19 regulations were understood and being complied with (unpublished data). The platform is ISO-27001 and General Data Protection Regulation (GDPR) compliant for data security and privacy. ISO-27001 is an international standard on how to manage information security via a risk-based approach (Wikipedia 2021). In contrast, the GDPR aims to protect personal data and enable compliance.

Implementation process

Service agreement

A service agreement was entered between South Western Sydney Local Health District (SWSLHD) and Curious Thing, Pty. Ltd., which included and incorporated payment of fees and terms and conditions. The service agreement covered the agreed technical services and supports, restrictions and responsibilities, and the proprietary rights.

In SWSLHD, the Primary and Community Health COVID-19 Response Team undertook an initial phone assessment to provide the COVID-19-positive patients information on how to self-isolate and identify if they were suitable for self-management and virtual home monitoring (South Western Sydney Local Health District 2021). The patients would then receive follow-up reviews based on their risk assessment to ensure that they remain clinically stable. These follow-up reviews were conducted by clinicians or through an automated service (Curious Thing). Low–moderate risk patients suitable for reviews by CT following initial assessment on Day 1 of infection, were followed up by CT from days 2 to 13 of infection.

Follow-up phone reviews were determined by the patients' level of clinical intervention to ensure that they remained clinically stable in the community.

- Risk Level GREEN – Nurse-led care with daily/second daily calls of short duration.
- Risk Level AMBER – Twice daily calls (voice/video), symptom questionnaire, assessment and pulse oximetry, to monitor no acute respiratory symptoms or shortness of breath. Determine signs of acute deterioration.
- Risk Level RED – Team-based care including twice/thrice calls per day, to monitor mild respiratory tract symptoms and/or cough. Determine signs of acute deterioration.

Process of co-design

In early September 2021, a four-step co-design initiative was conducted between the clinicians and administrators of the SWSLHD and the Chief Technology of Curious Thing to develop, refine the technology and the iteration process. The purpose for the co-design initiative was to undertake an alternate approach to manage the large number of Risk Level GREEN category patients identified in the SWSLHD. The steps were: (1) clinicians understanding the capabilities of the CT platform; (2) clinicians and CT discovery workshops; (3) staff training; and (4) testing and go-live with support. The discovery workshops were particularly critical to refine the technology and the iteration process, where knowledge of what was required was imparted to the CT team and ultimately built into the AI. During these sessions, the requirement from the clinicians and the customer experience team of CT were identified, discussed and confirmed. The discovery workshops also included setting escalation thresholds and frameworks. The AI was designed in this instance not to make any decisions, but to gather information required for clinicians to make decisions on appropriate next steps considering the patients' risk and wellbeing. During the workshops, the participants confirmed the voice personas and customised the voice AI so it fitted the tone and personality of our organisation and targeted customers. The AI technology was proactively engaging with the patients and getting them talking. Using machine learning with the data gathered, it had provided valuable information to make better clinical decisions. CT and its platform analysed data, with insights presented an on easy-to-understand dashboard tailoring to the organisational needs.

The design, build and testing of the CT solution was completed within 1 week and subsequently went live. A series of quality assurance activities were conducted to enable the success, which included clinical evaluation, testing and troubleshooting of the virtual call environment. The CT team delivered and supported the implementation of voice AI technology for monthly proactive phone calls with enrolled patients. It included the provision of a required phone number, AI technology, and support needed for ongoing study and analytics.

Patient selection for CT and the calling process

Patients for CT were identified via an initial clinical assessment by the COVID-19 Response Team from the unregistered list of the New South Wales Patient Flow Portal (New South Wales Health 2021). COVID-19-positive patients were triaged to one of three clinical interventions. Change in the level of intervention was reviewed at each clinical occasion of care. Selected patients for CT must fit the Risk Level GREEN category (NSW Agency for Clinical Innovation (ACI) 2020; South Western Sydney Local Health District 2021) with disease severity as:

- No symptoms or mild respiratory tract symptoms or cough, new myalgia or asthenia without shortness of breath or a reduction in oxygen saturation.
- No presenting clinical features suggesting a complicated course illness.
- Stable clinical picture.

Initial assessment

The clinicians from the SWSLHD COVID-19 Response Team would identify if the patient was suitable for CT at the initial assessment. The criteria for being accepted into CT was a patient who had been risk stratified as low–moderate risk, and a Level Green category (NSW Agency for Clinical Innovation (ACI) 2020; South Western Sydney Local Health District 2021). Patients who were double vaccinated were automatically risk stratified as low–moderate risk and thus

suitable for CT unless otherwise contraindicated. The patients were required to have a moderate-to-good understanding of English and must have a mobile or fixed phone with no incoming call restrictions.

Procedures for enrolling eligible patients and follow up

Those patients identified as suitable for the CT follow up were invited by the clinician to participate in the program at their initial call. The patients were provided with the procedure for engagement of CT. They were made aware of the process and that they would be contacted daily with a series of open- and closed-ended questions related to their medical symptoms and social setting by a care robot named 'Sam the AI', which included: (1) receiving a text message 10 min before the AI calls them; (2) when the AI calls them, they were required to answer the questions clearly with a 'yes' or 'no'; (3) if they responded to the AI indicating they required assistance, a clinician would call them back. Table 1 outlined the call flow and outcomes using these questions. The patients were entered into the CT team on the SWSLHD Dashboard as a clinical location. A Day 14 clinician call was booked to assess for eligibility for de-isolation, as per COVID-19: control guideline for public health units (2022). The administrative officer from the COVID-19 Response Team filtered the patient list at Day 2 to Day 12 and uploaded this into the CT AI platform for call generation. Uploaded triaged patient data were entered onto the CT platform before 10.00 h each day. A CT-generated short message service (SMS) was transmitted to the patient's mobile phone 15 min before the first call on Day 2 to Day 13. The workflow was automated as below:

- At 11.00 h each day 'Sam the AI' calls were made.
- At 12:00 h the calls were resent to the patients who did not answer the call the first time of transmission.
- At 12:15 h, a report was filtered by a trainer administrative staff member and was sent to the rostered COVID-19 Response Team senior nurses for action and escalation and to address both urgent and priority calls.
- This workload in the format of a spreadsheet was posted at 12:30 h to the CT Allocation folder in Microsoft Teams for access by the relevant staff.
- The clinicians accessed the spreadsheet for the current day and placed their name next to the patient they will work on and move down the list accordingly.
- This workload had two parts to it. At 12:30 h, the calls requiring an urgent (Red) response from the first call attempt with the patient will be posted, which need to be actioned within the hour.
- The second workload had the urgent responses from the second call attempt with the patient, as well as all the patients identified from either the first or second call as Priority (dark blue), Review (Green), Unanswered or Busy (both purple) and a Hang up prior to answering any questions (light blue).
- The priority and review transcripts were reviewed by the clinicians and clinical judgement was used to decide if the patient needed a follow-up call.
- If the patient had answered all of the symptom questions appropriately and there is no clinical escalation required

Table 1. Call flow and outcomes.

#	Question	Outcome in data
	INTRODUCTION	
1	Do you have someone at home who is able to help you with frequent monitoring?	
2	Are your symptoms getting worse since we last spoke with you?	If Yes: END CALL (with script) and flagged Urgent in export
3	Do you have a pulse oximeter?	Yes: to 3a; No: to 4
3a	Is your Oxygen level below 95, or your heart rate above 120?	Yes: flag
4	Are you short of breath?	Yes: flag
5	Do you have chest pain?	Yes: flag
6	Are you having trouble keeping your fluids up?	Yes: flag
7	Are you experiencing diarrhoea more than four times a day?	Yes: flag
8	Do you have any other symptoms that are concerning you?	Yes: flag
9	Last two questions now. Do you need any help with medication supplies for other conditions?	Yes: flag
10	Being in isolation can be challenging. If you experience difficulty coping, have trouble accessing the things you need, or you require further assistance, we can arrange for one of my humans to call you. Do you need to speak with someone about any other matters?	Yes: flag
	CLOSING	

but they used words instead of Yes/No, a call was not necessary.
- If the patient answered Yes to 'others unwell', a clinician call was needed.
- In the first workload, urgent responses were prioritised. In the second workload, the responses were prioritised: (1) urgent; (2) priority; (3) unanswered, busy, no connection, voicemail, reject by carrier; (4) review; and (5) hang up prior to answering any questions.
- The clinician located the patient on the dashboard by filtering to the CT team and using the patient surname.
- The clinician would follow the usual business practice of contacting the patient, completing the follow up and clinical escalation, if required.
- The clinician would document on the follow-up form as either: (1) continue on the CT pathway and confirm the Exit Day appointment (Day 14 call) was booked on the tracking list and with the patient; (2) if the patient became unsuitable for CT, move them out of the CT pathway and the Team would make the appropriate day follow-up call appointment.

Escalation to a clinical response from Risk Levelamber or red

Amber category

If the patient had deteriorated and the risk stratification changed to the Amber category, the risk category on the follow-up form would be changed to high risk, and the clinical support team phone call follow up for 9:00 h the next day would be confirmed. An escalation email to the generic email inbox would be sent. The clinician would make the first call to the patient in the morning. If suitable for an AI call in the afternoon, the AI would make two (2) attempts to call the patient at 14:15 h and 14:45 h on Day 2–13.

Red category

If the patient had deteriorated and the risk stratification changed to the Red category, the clinical support team would be called immediately for clinical advice, the risk category on the follow-up form would be changed to very high risk and the clinical support team would arrange an urgent follow-up call or further escalation.

If the patient had improved and the risk stratification changed to the Green category, the risk category would be changed on the follow-up form to low–moderate and add a note to the CT team for an AI follow up and book a Day 14 call.

Data analysis

Between 2 September and 14 December 2021, there were 32 001 conversations (every phone call that resulted in a conversation with a patient) conducted with 6323 unique patients engaged (patients included in call lists were identified by their phone number). Twice weekly team meetings were conducted to ensure the implementation of the initiative went smoothly and allowed modification of the initial campaign a few weeks after. Overall, 17 478 (61.7%) calls did not require follow-up calls, and after optimising the script and processes in place, the rate had increased to 71.1% (n = 2633) (Table 2). Over half of the completed calls (n = 13 143, 53.7%) identified that individuals needed no further support (freeing up valuable clinician time); and 4.24% (n = 1077) were identified as needing urgent support (getting to them faster than a standard clinician dialling pattern).

The contact rate was defined as the percentage of call attempts that resulted in a conversation. The contact rate for the initial campaign was 73.03% and the rate was increased to 86.45% when the campaign was modified after a few weeks by optimising the script and process es in place (Fig. 1).

The common flags determined by the script as a resultof the questions asked during the phone calls are summarised in Table 3. The reasons for urgent follow up by clinicians included: worsening of patient symptoms due to COVID-19, or patients requesting follow up mainly becauseof someone else in their household being unwell.

What can be learnt from this case?

Due to the unknown, but very large scale of COVID-19 infection in the population, the capacity for clinicians to understand which patients require their time is vital. The level of risk and wellbeing for each patient is always the main driver, with many patients experiencing less threatening symptoms. One of the biggest risks is time spent validating patients who are comparatively 'okay', but failing to be identify when they are suddenly deteriorating. During a conversation, it may become apparent that the patient requires an urgent follow up, and an alert is triggered for a clinician to immediately engage directly with the patient. Other patients' responses may trigger 'flags' or specific calls to attention for the clinicians to review, interpret and act upon. The reporting, which includes full call transcriptions, allows analysts to review and determine opportunities for efficiency and optimisation.

Patients who are deemed unsuitable for the AI conversation agent model due to them experiencing more significant symptoms, continue to receive the daily call from the COVID-19 Response Team. The completed calls that identified individuals needing no further support has freed up valuable clinician time for the higher risk groups. Ultimately, the platform represents another symptomatic diagnostic tool to be used by clinicians to deliver the best possible care.

The 'unclear' or 'No' response from the patients caused additional follow up and requires further refining. This

Table 2. Breakdown of the status of the calls to patients.

		GREEN Version 1		GREEN Version 2		Combine GREEN Version 1 and Version 2	
Status	**Category**	**Count (*n*)**	**%**	**Count (*n*)**	**%**	**Count (*n*)**	**%**
Complete	No further action	10 966	38.77	2177	58.84	13 143	53.70
	Priority follow up	4252	15.02	384	10.37	4636	18.94
	Review required	5330	18.83	327	8.83	5657	23.12
	Urgent	953	3.36	84	2.26	1037	4.24
Complete total		21 501	75.98	2972	80.30	24 473	76.48
Partial	Customer exited part way through	984	3.49	116	3.14	1100	3.43
	Priority follow up	190	0.67	10	0.27	200	0.62
	Review required	198	0.69	13	0.35	211	0.65
	Voicemail left	5427	19.17	590	15.94	6017	18.80
Partial total		6799	24.02	729	19.70	7528	23.52
Complete and partial complete	No further action	11 950	42.23	2293	61.96	14 243	44.51
	Priority follow up	4442	15.70	394	10.65	4836	15.11
	Review required	5528	19.53	340	9.19	5868	18.34
	Urgent	6380	22.54	674	18.21	7054	22.04
	Total	28 300	100	3701	100	32 001	100

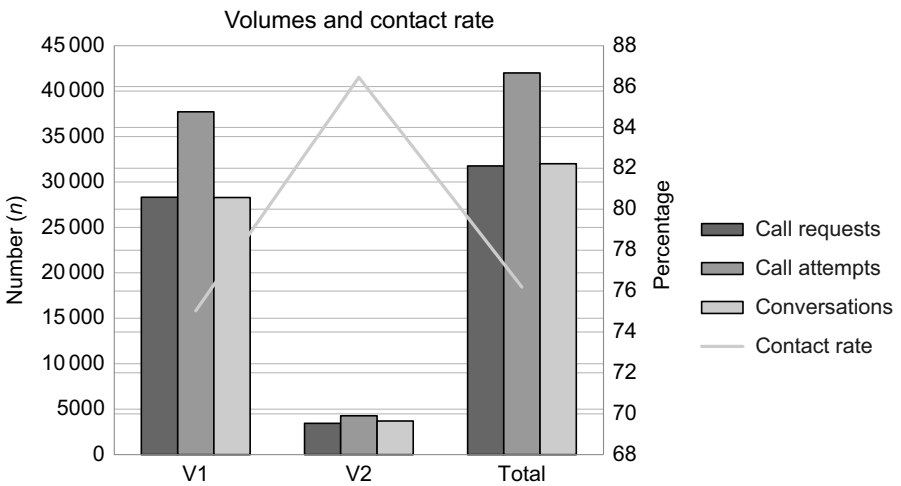

Fig. 1. Volumes and contact rate (V1, version 1; V2, version 2).

Table 3. Flags by script questions.

Symptoms	Follow-up request (*n*)	Urgent follow-up request (*n*)
Symptoms worse	12	898
Short of breath	1	597
Chest pain	1	318
Problems with fluids	0	198
Diarrhoea	345	226
Other symptoms	231	238
Anyone else unwell	3203	1250
Help with medications	332	431

means that 'other' and 'unclassified' responses will raise flags for the clinical team to review. If this tuning was changed to only flag if a clear 'Yes' is returned, it would have reduced the number of follow-up calls required to be made by the senior nurses.

Conclusion

Based on the severity of COVID-19, different approaches have been adopted by healthcare professionals for handling patients in the most effective manner. This paper describes the AI-assisted conversational agent, which can act as an

alternate approach to identify deteriorating patients requiring further support while they are isolated at home.

The findings are intended to inform policymakers and health professionals about the implications of the use of these AI-based technologies for the management of current or any future pandemic patients.

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