Original research

Scoping and testing rural acute care at home: a simulation analysis

David M Levine ,[1,2,3] Meghna P Desai ,[3] Joseph B Ross,[3] Natalie Como,[4] Steve Holley[5]

► Supplemental material is published online only. To view, please visit the journal online (http://dx.doi.org/10.1136/bmjinnov-2020-000592).

[1]Division of General Internal Medicine and Primary Care, Brigham and Women's Hospital, Boston, Massachusetts, USA
[2]Harvard Medical School, Boston, Massachusetts, USA
[3]Ariadne Labs, Boston, Massachusetts, USA
[4]University of Utah Health, Salt Lake City, Utah, USA
[5]Utah Valley University, Orem, Utah, USA

Correspondence to
Dr David M Levine, Brigham and Women's Hospital, Boston, Massachusetts, USA; dmlevine@bwh.harvard.edu

Received 18 November 2020
Revised 19 January 2021
Accepted 27 January 2021

Check for updates

© Author(s) (or their employer(s)) 2021. No commercial re-use. See rights and permissions. Published by BMJ.

To cite: Levine DM, Desai MP, Ross JB, *et al*. *BMJ Innov* Epub ahead of print: [please include Day Month Year]. doi:10.1136/bmjinnov-2020-000592

ABSTRACT

Purpose Hospital-level care provided at home improves patient outcomes, yet nearly all programmes function in urban environments. It remains unknown whether rural home hospital care can be feasibly delivered.

Methods Based on prior stakeholder learning and detailed landscape analyses of various rural areas across the country, we re-engineered the workflows, personnel and technology needed to respond to many of the challenges of delivering acute care in rural homes. We performed a preliminary 'mock admission' in a simulation laboratory with actor feedback, followed by mock admissions in rural homes in Utah of chronically ill patients who feigned acute illness. We employed rapid cycle feedback from clinicians, patients and their caregivers and qualitative analysis of participant feedback.

Findings Following rapid cycle feedback in the simulation laboratory and rural homes, mock admission, daily rounds and discharge were successfully conducted. Technology performed to laboratory-determined specifications but presented challenges. Patients noted significant comfort with and preference for rural home hospital care, while clinicians also preferred the model with the caveat that proper patient selection was paramount. Patients and clinicians perceived rural home hospital as safe. Clinicians noted rural home hospital workflows were feasible after streamlining remote and in-home roles.

Conclusions Rural home hospital care is technically feasible, well-received and desired. It requires testing with acutely ill adults in rural settings.

Summary box

What are the new findings?

- Illness that traditionally requires hospitalisation represents a common critical moment in nearly every person's life. Rural home hospital is a disruptive care delivery model that adapts the urban home hospital principles by implementing innovative technologies, top-of-license personnel and novel workflows to deliver high-value acute rural care for rural patients, who face geographical, financial and cultural barriers to accessing acute care in traditional hospital settings.
- Following rapid cycle feedback in the simulation laboratory and rural homes, mock admission, daily rounds and discharge were successfully conducted. Patient and clinicians perceived rural home hospital as safe, workflows as feasible and patients noted comfort and preference for rural home hospital care.

How might it impact on healthcare in the future?

- We have designed appropriate training, scope of practice, and workflows for nurses, physicians, paramedics, and other healthcare professionals in this unique acute care at home setting. If successful, such a model would likely ameliorate issues surrounding access, safety, quality, experience and cost in rural areas and would entirely reimagine a decentralised acute care delivery model.
- Learnings from this phase of the work will inform future iterations and testing of the rural home hospital model.

INTRODUCTION

For the 1 in 5 Americans living in rural areas, totalling nearly 60 million people, it can be challenging to receive hospital-level care.[1] The hospital may be located miles away, emergency services may not be reliably available for transport, or care may not be accessible at all due to hospital closure.[2–5] Even when a hospital is available, its use may be associated with significant adverse events, owing to the site of care.[6–11]

BMJ Innov: first published as 10.1136/bmjinnov-2020-000592 on 24 February 2021. Downloaded from http://innovations.bmj.com/ on April 23, 2024 by guest. Protected by copyright.

Many urban healthcare systems have chosen to adopt a home hospital model that provides hospital-level care at home as a substitute for the traditional hospital.[12 13] Home hospital programmes typically provide a full suite of services that would normally be delivered in a hospital, including nurse and physician visits, intravenous medications, remote monitoring, video communication and point-of-care testing.[13] Conditions treated include the most common reasons for internal medicine admission: infection, exacerbation of heart failure, asthma, and chronic obstructive pulmonary disease, and others. Randomised controlled trials[14 15] and quasi-experimental evaluations[16–18] have shown significant improvements in cost, 30-day readmission, physical activity and experience for patients hospitalised at home compared with a traditional hospital.

Despite the success of urban home hospital programmes, rural areas have rarely trialled this innovation. While some factors may make rural areas an ideal setting for a home hospital, including the provision of lower cost agile capacity, other factors have undoubtedly prevented home hospital, including travel burden and connectivity.

We recently described rural perceptions of home hospital care through a series of qualitative interviews and a focus group with rural clinicians and patients, demonstrating interest and perceived acceptability among clinicians and patients in rural America.[19] We took key learnings from these stakeholders to iterate on the design requirements of how home hospital care might function in rural America. To prepare a plausible rural home hospital model, we tested our assumptions of the personnel, workflows and technologies required through simulated 'mock admissions' first in a lab setting and then in rural homes of chronically ill patients who feigned acute illness and had been hospitalised previously.

METHODS

Study design, participants and data sources

Based on key learnings from stakeholders[19] and detailed landscape analyses of various rural areas across the country (example in online supplemental), we re-engineered the workflows, personnel and technology needed to respond to many of the challenges of delivering acute care in rural homes. We then performed a preliminary mock admission in a simulation laboratory with actor feedback and study team observation to further iterate the model and test various designs.

To test the feasibility of rural home hospital care in the intended setting, we subsequently performed mock admissions in regions of rural Utah. We defined rural as an area that falls within the following criteria: rural–urban commuting code (RUCA) 4–10, frontier and remote area code (FAR) less than or equal to 4 and Centers for Medicare & Medicaid Services ambulance fee schedule of 'super rural' (emergency medical services (EMS) super rural). We defined super rural as an area that falls within the following criteria: RUCA 10, FAR 4 and EMS super rural.

We recruited two patients from the University of Utah Health who lived in a private residence in rural Utah, had capacity to consent and had a chronic illness that had at least once prior resulted in an acute hospitalisation. We asked participants to feign an acute exacerbation of their chronic illness drawing from their lived experience with details added by the study team (cases in the online supplemental). We then deployed the home hospital model to the patient's home in a simulated mock admission. The study team was present in the patient's home to observe all interactions, noting in real-time strengths and areas of improvement with respect to workflow, personnel and technology. Using a rapid cycle feedback approach, the home hospital team 'admitted', 'rounded on' and 'discharged', each patient multiple times to allow for iterative improvement and learning. After each segment (admission, daily rounds and discharge) was completed, we asked all clinicians, the patient and their caregivers for formative feedback through a semistructured qualitative interview, focusing on what went well and what could be improved (interview guide in the online supplemental). If possible, we made recommended changes in the next iteration. We continued to repeat a segment until saturation (ie, repetitions of a segment ended when the study team felt another repetition would not yield further insights). The entire mock admission experience lasted a full day. At the end of the entire mock admission, we asked participants for their summative feedback through a semistructured qualitative interview (interview guide in the online supplemental). Patients did not have a prior relationship with the interviewers and were not told interviewers characteristics. Interviews were conducted in-person by trained qualitative interviewers (DML: MD, MPH, principal investigator, male; MPD: MPH, research assistant, female). Interviews were only conducted in English.

Key baseline features of the rural home hospital model

Prior to learnings described in this study, the rural home hospital model included a remote physician guided by a mobile integrated health paramedic or nurse (heretofore 'in-home clinician'), advanced point-of-care testing including blood diagnostics and ultrasound and continuous biometric monitoring (figure 1). The model also included a health monitoring device which provided continuous physiological measurements to the clinical team in real time. The model includes dedicated in-home medication storage as well as pharmacy and durable medical equipment home delivery. Care workflows designated patient assessment and remote physician consultation procedures for admission, daily rounding and discharge. Internet connectivity was ensured through a cascading approach that sought to prioritise fast and easily available systems first.

BMJ Innov: first published as 10.1136/bmjinnov-2020-000592 on 24 February 2021. Downloaded from http://innovations.bmj.com/ on April 23, 2024 by guest. Protected by copyright.

Figure 1 Key features of the rural home hospital model. (A) Physician performs remote facilitated history and physical. (B) Kitchen walk-through to discuss low sodium foods with remote physician. (C) Point of care ultrasound delivered in real-time to physician. (D) Portable satellite communication system set up in front yard. (E) View from patient's front yard. All persons pictured gave permission for use of images.

We therefore would access, and if necessary deploy-systems in the following order: in-home broadband (digital subscriber line, cable or integrated services digital network), smart-device cellular, 4G antennae, and finally portable broadband global area network satellite.

Qualitative analysis

All clinician and patient qualitative interviews were audio recorded and then transcribed verbatim. All participants gave written informed consent to participate.

Our analytical approach borrowed from grounded theory, which involves open coding (comparing and conceptualising the data), followed by axial coding (forming groupings based on relationships in the data), and then finally selective coding (describing central themes).[20 21] A codebook was developed based on the first three interviews and subsequently refined throughout the coding process to create domains and subdomains.

The transcripts were analysed using two-person consensus (MPD, JBR). One investigator coded each interview (MPD) using qualitative analysis software (NVivo V.12, V.12.2.0) and a second investigator (JBR) reviewed each coded transcript. Throughout the process, the two investigators (MPD, JBR) debriefed with each other to clarify concepts and refine codes, with oversight from DML. Any discrepancies in coding were discussed and finalised by consensus. Following this analytic approach, we finalised central themes and used our learnings to inform the development of the rural home hospital model.

Patient and public involvement

Patients were involved in the testing of this innovation, and their feedback will continue to drive the model.

Table 1 Challenges and solutions to rural home hospital care delivery

	Challenge*	Solution
Internet connectivity	Poor cellular and wired infrastructure	Tiered approach to connectivity, including portable satellite
Geographical accessibility	Lengthy travel times between patients	Optimise use of remote visits for in-home clinician; physician only remote
Staffing	Limited availability of physicians and in-home clinicians	Physician remote only; use novelty of programme as selling point for in-home clinician
Clinical workflows	Not optimised for remote physician	Optimise through rapid cycle feedback
Laboratory and imaging	Lengthy travel times	Point of care ultrasound and laboratory technologies
Specialty expertise	Limited availability	Provide remote physician consultation

*Challenges identified from prior work.[19] Solutions developed through scoping, testing, and rapid cycle feedback.

RESULTS

Preliminary mock admission in a simulation centre

After significant research and field observations, we recognised several key design elements necessary to answer the challenges of deploying rural home hospital care (table 1). We tested Internet connectivity under various bandwidth stressors. We noted that various communication software platforms performed adequately for video at 50 kb/s, audio at 25 kb/s and text message at 2.5 kb/s. We tested various Internet connection options, including cellular 4G, 4G antennae, portable broadband global area network satellite and satellite telephones. 4G options worked optimally, portable satellite produced usable but choppy video, and satellite telephones allowed for clear bidirectional audio.

We ran and repeated our workflows for admission (welcome, technology set-up and clinical intake), daily rounds (one morning in-home clinician visit followed by a virtual (if possible) afternoon visit for clinical management), and discharge (coordination) multiple times, enabling us to fine-tune and optimise workflows. Total admission workflow required approximately 45 min. Learnings included the need for a Bluetooth speaker, tablet stand, satellite extension cable and parallel workflow for physician and in-home clinician, with the physician performing a history while the in-home clinician set up systems and collected data. Daily rounding required approximately 25 min after streamlining workflows so that the in-home clinician collected vitals prior to initiating the video call with the physician. Discharge required approximately 25 min, similar to daily rounding. However, this did not account for the time required to disconnect and clean all equipment used for the home hospitalisation and provide patient postdischarge instruction. These exercises facilitated the creation

BMJ Innov: first published as 10.1136/bmjinnov-2020-000592 on 24 February 2021. Downloaded from http://innovations.bmj.com/ on April 23, 2024 by guest. Protected by copyright.

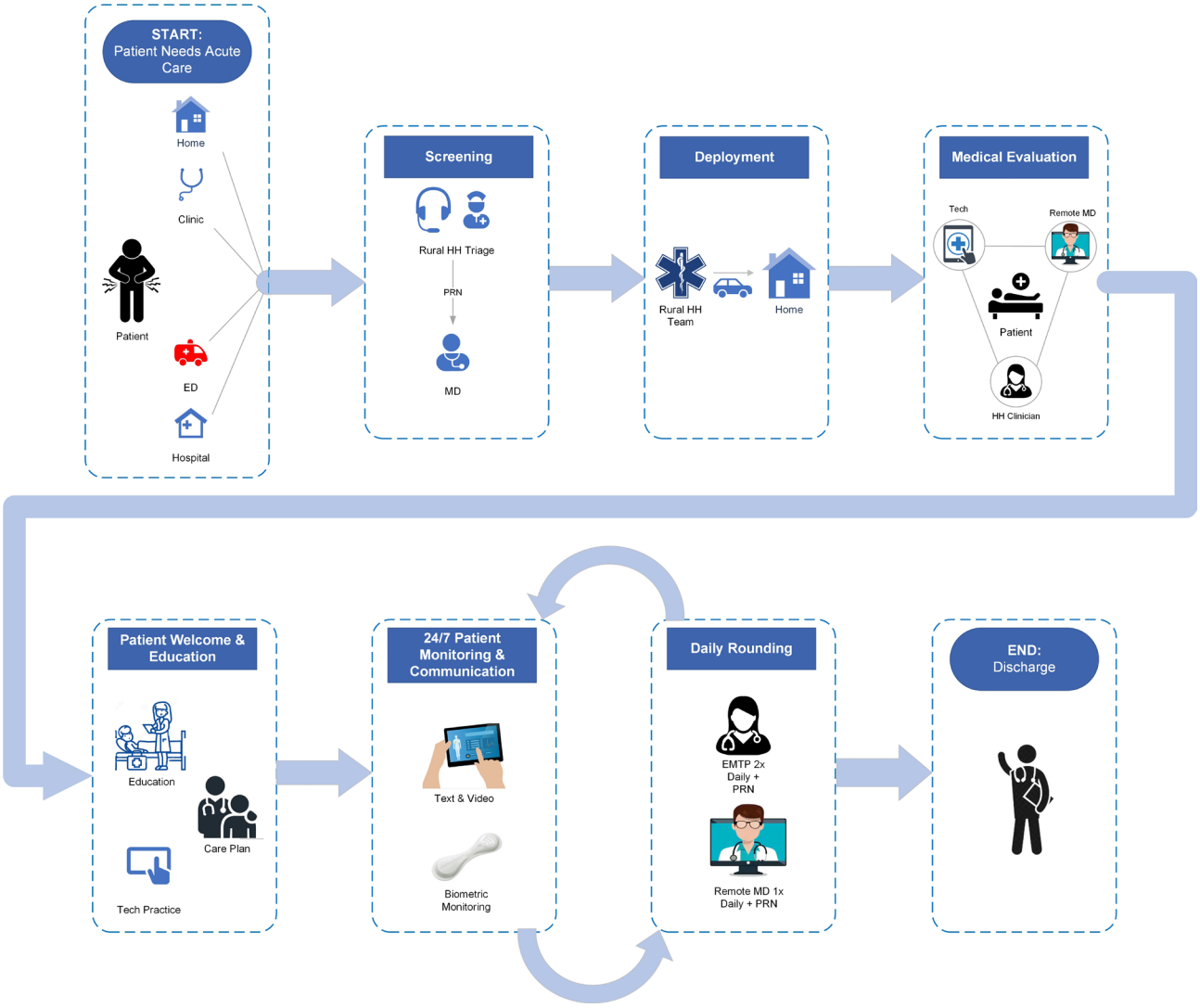

Figure 2 Workflow map for rural home hospital. ED, emergency department; EMTP, emergency medical technician paramedic; HH, home hospital; MD, medical doctor.

of workflow maps for the rural home hospital care model used to guide the mock admissions in rural Utah (figure 2).

Study team observations during mock admissions in rural Utah

Study team members noted the cascade approach to Internet connectivity demonstrated adaptability and resilience to conditions encountered in the home. Video conference calls between the patient and physician were achieved with high audio–visual quality using in-home broadband, smart devices with native cellular connections, 4G antennae and satellite. Bandwidth limitations arose, including data lag and freezing, when transmitting biometrics, point of care ultrasound and video conferencing simultaneously. The team noted the simplicity, reliability and performance of 4G antennae set-up when other non-satellite options were unavailable. The use of in-home Internet systems, while cost effective and typically reliable but not always present, created a dependency between the in-home clinician and patient and/or their caregiver who may not be able to assist or guide the connection process and were slower to establish. 4G connected devices required the least amount of time and effort to deploy but were heavily impacted by bandwidth fluctuations and showed significant video lag when attempting to connect to multiple devices and/or be used as hotspots. Study team members also noted that in general patients had limited technology literacy, requiring the facilitation of the in-home clinician for nearly all tasks. Larger screens with loud audio and single screen taps and friendly user interfaces would be high yield.

Study team members noted that the physician–patient interaction was inefficient prior to rapid cycle feedback, with repetition between the in-home clinician and the physician. Streamlining roles for each clinician before, during and after the video improved timing and teaming.

BMJ Innov: first published as 10.1136/bmjinnov-2020-000592 on 24 February 2021. Downloaded from http://innovations.bmj.com/ on April 23, 2024 by guest. Protected by copyright.

While conducting the admission, daily rounds and discharge workflows with mock admissions patients, the study team introduced various stressors to test and improve on the technology approach. Simulations included a sudden failure of the in-home Internet, power outage, low and fluctuating cellular signal and unexpected video failure. By using 4G connected devices and satellite, disruptions to in-home power or Internet services were mitigated. Weak cellular services had the greatest impact. Video failure, due to power outage or weak cellular service, necessitated deployment of satellite. Clinicians responded favourably to the use of satellite to maintain patient monitoring telemetry when coupled with in-home, cellular or satellite phones to provide an audio connection between the patient and the physician. When video was needed after an Internet or cellular failure, satellite provided satisfactory audio–visual video quality to execute all workflows, but all other Internet usage had to be halted during the video call.

Patient and clinician formative feedback

The in-home clinician reported that communication and task management with the physician was strengthened through the use of an online task management system which allowed the physician to provide updates to the patient's care plan in real time. The physician identified the need for a preadmission or deployment protocol when the patient's electronic health record is reviewed. Such a protocol might also include a brief preassessment check-in between the physician and the in-home clinician to share any concerns and confirm if any changes to the standard admission workflow process would be advisable. The physician emphasised the importance of having high resolution video for conducting the patient assessment.

A patient noted that being in the home allowed for new ways of interacting with the care team, giving the example of a kitchen walkthrough, where the patient learnt about high-sodium foods in the kitchen as the cause of a heart failure exacerbation. Patients felt that continuity of care during their admission would be better in rural home hospital than the hospital. During discharge, patients also expressed a desire for a clear handoff between their rural home hospital team and any subsequent recommendations for follow-up clinical care.

Patient and clinician summative domains

Three domains emerged in which clinicians, patients and caregivers expressed views on their experience with the rural home hospital mock admission: (1) comfort level during rural home hospital, (2) perceived safety during rural home hospital and (3) perceptions of rural home hospital workflow (table 2).

Comfort level during rural home hospital admission

Patients and caregivers expressed a preference for home versus traditional hospitalisation for acute illness: 'I really hope that I will be able to stay in my home until I die. I don't want to be someplace else. And I don't want my husband to be someplace else either.' They also noted that rural home hospital meant significantly less time spent waiting in an unfamiliar and uncomfortable hospital waiting room or hospital bed (table 2, 1a). They cited the patient centeredness of the rural home hospital model: '[E]verybody's right here helping and watching and checking.' This allowed for a comfort and ease they had not experienced previously: '[H]aving someone that you could call that could come [would be] a lot easier than…go[ing] up to the hospital. It sometimes gets to be really hard… mostly in the winter, when it's cold and miserable…I undoubtedly get pneumonia or get sick or something.'

The in-home clinician expressed that the rural home hospital model did not put 'any undue stress or burden' on the patient. He noted that his comfort level improved between the first and second mock admission secondary to having more experience and practice with processes and the technology. The physician expressed that she, 'liked that the patients were really happy staying in their home'. She also explained that a challenge with the admission process could be initial diagnostic uncertainty, given the patient does not receive a complete emergency department workup, and she was not able to be physically present for an exam (table 2, 2a).

Perceived safety during rural home hospital

Both patients and caregivers felt that care was being delivered safely during their rural home hospital mock admission. Patients were comfortable with a remote physician: 'I feel like she was able to do her job by knowing the facts, …what was wrong, and what could be done for it.' One patient described that due to the inconvenience, she often delayed seeking hospital care (table 2, 3b). The patient went on to describe that having the option to receive hospital-level care at home would make her more likely to seek timely care.

The in-home clinician felt that care was delivered effectively and safely 'in every way' during the mock admissions. One potential safety concern raised by the in-home clinician was inclement weather making driving to patient homes challenging. The physician felt that 'going into people's homes is insightful about how they take their medicines'. She noted it allowed her to identify safety issues: [Patient] med[ication] boxes are a mess, and it gives you so much insight into a patient's life and what's realistic for them to do and not do when you actually see them in their home environment'. She suggested use of a shared medical record and involvement of a remote pharmacist would serve

BMJ Innov: first published as 10.1136/bmjinnov-2020-000592 on 24 February 2021. Downloaded from http://innovations.bmj.com/ on April 23, 2024 by guest. Protected by copyright.

Table 2 Domains, subdomains and illustrative examples of summative patient and clinician mock admission experience

Domain	Subdomain	Illustrative example
Comfort level during rural home hospital admission	Patient and caregiver perspective	Patient: "[When y]ou have to go to the hospital, it's such a big hassle." Caregiver: "And you sit there and sit there. Well, [with home hospital] …you're at home where you feel comfortable." Patient: "Yeah. I get a phone call this morning saying, 'We're on our way.' You might be waiting, but at least you're waiting at home, right?" (**1a**)
	Clinician perspective	Physician: "[T]he only part that made me nervous with the admission or I think has the potential to make me nervous with other admissions like this is just that initial diagnostic uncertainty… [A]s long as we're sure about the diagnosis then I felt really comfortable moving forward… It's just that initial, 'Is this heart failure or is this COPD?' [S]omething that could help with that in real life would be if the patient's cardiologist called me and said, 'I know this patient really well. They always have heart-failure exacerbations. If they have symptoms, they're having another exacerbation, can we do the Home Hospital?" [T]hen I would feel more confident, or if the patient initially went to the ER and had some diagnostic work-up and then I had that data, then they could start the admission, that's something that'd make me feel more comfortable too. [When you're diagnostically uncertain], you just need to physically be there and put your hands on the patient and listen yourself." (**2a**)
Perceived safety during rural home hospital admission	Patient and caregiver perspective	Patient: "There have been times when I knew I had to be in the hospital because I couldn't breathe at all, and I needed the doctor. And the doctor said, 'You waited too long,' because I had waited until I was really bad sick before I went to hospital." (**3b**)
	Clinician perspective	Physician: "I'm… used to in the hospital… having a pharmacist verify med[ication]s, and a lot of times they come up with crazy discrepancies that I don't even know about." (**4b**)
Perceptions of rural home hospital workflow	Inefficient processes	Physician: " I think [the in-home clinician] was very well-meaning in asking a lot of his questions, but I felt like he tried to sort of do his own H&P and then called me, and I felt like it could have duplicated things and the patients felt like they were repeating stuff." (**5c**)
	Efficient processes	Patient: "I think today I had good care. I really do… For what I had, I would've had to have sat in the waiting room unless I was really having a heart attack…I think that's rule number one. Make sure they sit in the waiting room for at least two hours…I thoroughly like this idea right here." (**6d**) In-home clinician: "I am just not used to having a physician spending as much time with a patient as we have here. If that's this model, it's a win-win. [I]f a physician can actually dedicate 15 minutes to a patient every day…, what a cherished thing." (**7d**)
	Team collaboration	Physician: "I think something that's a benefit of the Home Hospital is that [the in-home clinician] would be there… [to lay] out the patient's medicines for them." (**8e**)
	Technology	Physician: "[Similar to TeleStroke systems,] the doctor having control of that camera might be kind of cool, and then just working on the resolution so I could feel a little bit more confident about my physical exam." (**9f**)

as important additional safety measures (table 2, 4b). The physician also noted concerns with 'not being able to physically touch the patient', resulting in a physical exam that was 'not good' due to technology issues (camera aimed in the wrong direction, pixelation of video) and felt she needed to rely on the in-home clinician's physical exam. She expressed that the physical exam 'is a really valuable part of delivering safe care' and it was 'the main thing that was compromised'.

Perceptions of rural home hospital workflow

Inefficient processes

Patients made no mention of inefficiencies in their care. The physician suggested the need for streamlined workflows between the in-home clinician and physician to alleviate any duplicative history and physical exam activities (table 2, 5c). The physician also noted the tension of being available for the remote clinician while also tending to other patients' needs: '[Y]ou… have to be available at a computer whenever you're needed, so [it is harder to] multitask in between that'. Of note, both these issues improved after several rapid cycle improvements.

Both the physician and in-home clinician found switching between different technology platforms was inefficient: '[I]t was… annoying switching screens, and I felt like I ignored some of the screens because they weren't just all in front of me at once'. There were challenges with the digital stethoscope such that the physician felt it would be difficult to hear a heart murmur due to the poor quality of the patient's heart sounds.

Efficient processes

Patients and caregivers appreciated the efficiency of the rural home hospital model. As previously noted, every aspect of wait time was minimised including admission, daily rounds and discharge, and patients did not mind waiting in their own home with their loved ones (table 2, 6d). One patient cited an experience of inpatient diuresis and the struggle of having to wait to be disconnected from his IV: '[W]hen you're doing Lasix and when it says time to go to the bathroom, you ain't got no time to spare. And then you have to buzz them, takes them 10 minutes to come in and unhook you, … and then 10, 15 minutes to hook you back up'.

BMJ Innov: first published as 10.1136/bmjinnov-2020-000592 on 24 February 2021. Downloaded from http://innovations.bmj.com/ on April 23, 2024 by guest. Protected by copyright.

The in-home clinician enjoyed the 'unhurried feeling' of providing care and felt that being in the patient's home helped facilitate quality care: 'When you can get the patient in their environment and can see how they live…, I just think this is better. The environment tells me a lot about the patient…' He also noted the quality time that the remote physician was able to spend with each patient (table 2, 7d). During daily rounds, the physician liked that the in-home clinician could just contact her when he was ready with the information she wanted. Both noted the collaboration platform used in the mock admission helped make rounding efficient: 'I could just give a brief checklist of what data I wanted…, so then [the in-home clinician] can have that stuff ready ahead of time and make it efficient from my end…'

Team collaboration

The in-home clinician 'felt further removed' from the remote physician and said that 'this is not the same as face-to-face' where you can develop a relationship working physically side-by-side, although he also acknowledged that their remote interactions were extensive. He expressed that having met the physician in-person helped their working relationship when compared with only meeting over videoconference. Both noted trust among treating clinicians was paramount. The physician also noted the power of collaborating effectively, such that the in-home clinician could be the remote hand of the physician, performing detailed medication reconciliation and education (table 2, 8e).

Both noted rural home hospital needed to adapt to training differences among all clinicians. The physician expressed that paramedics may not have the in-hospital experiences that help them understand the data a physician is interested in, although she noted, 'I think that this would get better the more you work with somebody, and this was our first time doing it'.

Technology

Patients and their caregivers had no concerns with any of the technology, including the use of continuous patient monitoring. One patient preferred the rural home hospital monitoring compared with the traditional hospital because the monitoring was wireless.

The in-home clinician expressed that the wireless continuous patient monitoring technology was powerful and a 'very high-yield tool'. He felt that the 'learning curve was short' with some of the technology. He did express the need for more training and practice to become familiar with some of the technology and felt that by the second mock admission he had become better acquainted. The physician noted that better positioning of the camera in a patient's home so that she could see the patient's face, ability to control the camera's positioning, and improved resolution were all areas for enhancement (table 2, 9f). The physician noted she could see '[some] physicians struggling a little bit with the technology since there were so many different platforms that we were using'.

DISCUSSION

In this simulation analysis of rural home hospital, we demonstrate that acute care delivered in a rural home is technically feasible, acceptable to clinicians and delivers a positive patient experience. Given the dearth of evidence in rural home settings, we purposefully began with scoping exercises using a simulation laboratory and then moved to rural homes. Through a rapid cycle feedback approach, we fine-tuned workflows, personnel and technology deployments to enable acute care delivery in the rural setting.

Our work builds on the home hospital literature that suggests high-value care can be delivered to patients in mostly urban environments.[16 22] To our knowledge, few home hospital programmes operate in rural areas due to the challenges of geography and connectivity. With the use of the right technology and workflows, this scoping exercise demonstrates the possibility of rural home hospital care for a carefully selected patient population. It further builds on our recent work detailing rural patient and clinician interest in the care model.[19]

We identified the need for remote care physician training. Significant aspects of the physical exam can be performed by video, especially with a facilitator such as an in-home clinician, yet few physicians receive training in this method of patient assessment.[23 24] Multiple randomised controlled trials have found remote care non-inferior to in-person care.[25] Facilitated video interaction, coupled with point of care imaging and laboratory analysis, reduces physician uncertainty. When considering the workforce needs of the in-home clinician, it is likely that various clinical roles practising at the top of their license may fit the role well: mobile integrated health paramedics,[26 27] nurses, and highly trained community health workers.[28] Customising a programme to a local area's offering will be important.

Participant insights helped us to identify additional areas for improvement. Clinicians mentioned the challenge of using so many apps and systems, suggesting the need for a home hospital technology platform that unifies the various technologies under one ecosystem. We made great improvements in parallel workflows as we deployed rapid cycle feedback, further structure (perhaps in the form of checklists) can be helpful in optimising remote physician and in-home clinician workflow.

Finally, given the physician and in-home clinician may not always have synchronised schedules, care may be facilitated if the physician creates rule-based plans for the in-home clinician to follow. For example, diuretic dosing based on specific weights

BMJ Innov: first published as 10.1136/bmjinnov-2020-000592 on 24 February 2021. Downloaded from http://innovations.bmj.com/ on April 23, 2024 by guest. Protected by copyright.

would obviate the need for the in-home clinician to contact the physician during a second visit. It may be that rural home hospital requires additional communication norms than are typical of hospital-based care.

While potentially highly disruptive in how we deliver acute care in rural settings, the rural home hospital model, as all care models, is not a panacea. Just as in urban home hospital programmes, clinicians must be careful to select appropriate patients such that the programme's capabilities match the patient's needs. Not all acutely ill patients will be eligible for rural home hospital. Prior to admission, clinicians and patients should have a clear view of the risks and benefits of rural home hospital. A discussion should be had with the patient about the limitations of home hospital and how the model compares to traditional hospitalisation. For example, for a carefully selected patient, an emergency event has a very low likelihood, yet an adverse event in a hospital affects about one in ten.[29] Receiving care in a rural home may therefore carry fewer risks. The present model discussed in this simulation analysis begins in the home; however, several other admission pathways exist including the patient presenting acutely ill to a clinic or emergency department, or if a patient is admitted to the hospital and requires additional days of acute care and the patient is appropriate for home hospitalisation ('early transfer'). Finally, although cost in urban settings is demonstrably lower in multiple studies, teams need to consider the added cost in rural areas of travel and specialised communication technology compared with the cost of traditional hospitalisation. This requires further research.

Our study has limitations. First, we performed only two simulations in two rural regions of Utah involving two clinicians, limiting generalisability. Although rural areas share many themes, they each have unique pressures and variables. It may be that in some areas our designs will work better and in others worse. We did purposefully choose two highly rural areas in an attempt to stress the system as much as possible. In addition, other clinicians and patients may have different perspectives. Second, the clinicians participating in the simulation were accustomed to practicing in rural environments. It is possible that other clinicians may require additional training to perform well in this care model. Training should include using simulations with different scenarios including urgent and emergent situations. Third, given the simulated nature of this study, it is possible new improvements will be required to be made to the rural home hospital model. We anticipate future research will address this.

Our simulation analysis demonstrates the feasibility of delivering acute care in a rural home setting. We anticipate these findings represent the first step in driving a paradigm shift in the delivery of hospital-level acute care in rural America.

Twitter David M Levine @davidlevinemd

Acknowledgements The authors would like to acknowledge Kevin Carr for his assistance with workflow mapping.

Contributors DML, JBR, MPD: substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data for the work; and drafting the work or revising it critically for important intellectual content; and final approval of the version to be published; and agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. NC: the acquisition, analysis, or interpretation of data for the work; and drafting the work or revising it critically for important intellectual content; and final approval of the version to be published; and agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. SH: the acquisition, analysis or interpretation of data for the work; and drafting the work or revising it critically for important intellectual content; and final approval of the version to be published; and agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Funding This work was supported by an Ariadne Labs Spark Grant, Boston, MA.

Competing interests DML receives funding from Biofourmis for an investigator-initiated artificial intelligence study on deterioration of home hospital patients.

Patient consent for publication Obtained.

Ethics approval This study was approved by the Partners HealthCare and University of Utah Health institutional review board.

Data availability statement No data are available.

Supplemental material This content has been supplied by the author(s). It has not been vetted by BMJ Publishing Group Limited (BMJ) and may not have been peer-reviewed. Any opinions or recommendations discussed are solely those of the author(s) and are not endorsed by BMJ. BMJ disclaims all liability and responsibility arising from any reliance placed on the content. Where the content includes any translated material, BMJ does not warrant the accuracy and reliability of the translations (including but not limited to local regulations, clinical guidelines, terminology, drug names and drug dosages), and is not responsible for any error and/or omissions arising from translation and adaptation or otherwise.

ORCID iDs
David M Levine http://orcid.org/0000-0002-4337-9896
Meghna P Desai http://orcid.org/0000-0002-1159-7979

REFERENCES

1 UC Bureau. *What is rural America?* 2017.
2 U. S. G. A. Office. *"Rural Hospital Closures: Number and Characteristics of Affected Hospitals and Contributing Factors," no. GAO-18-634*, 2018.
3 "166 Rural Hospital Closures: January 2005 - Present (124 since 2010) - Sheps Center.".
4 Wishner J, Solleveld P, Rudowitz R. *A look at rural hospital closures and implications for access to care: three case studies*, 2016.
5 Frakt AB. The rural hospital problem. *JAMA* 2019;321, :2271.
6 Hung WW, Ross JS, Farber J, *et al*. Evaluation of the mobile acute care of the elderly (mace) service. *JAMA Intern Med* 2013;173:990–6.
7 2014 national and state healthcare-associated infections progress report 2016.

BMJ Innov: first published as 10.1136/bmjinnov-2020-000592 on 24 February 2021. Downloaded from http://innovations.bmj.com/ on April 23, 2024 by guest. Protected by copyright.

8 Callen BL, Mahoney JE, Grieves CB, *et al*. Frequency of hallway ambulation by hospitalized older adults on medical units of an academic Hospital. *Geriatr Nurs* 2004;25:212–7.
9 Fong TG, Tulebaev SR, Inouye SK. Delirium in elderly adults: diagnosis, prevention and treatment. *Nat Rev Neurol* 2009;5:210–20.
10 Boltz M, Resnick B, Capezuti E, *et al*. Functional decline in hospitalized older adults: can nursing make a difference? *Geriatr Nurs* 2012;33:272–9.
11 Counsell SR, Holder CM, Liebenauer LL, *et al*. Effects of a multicomponent intervention on functional outcomes and process of care in hospitalized older patients: a randomized controlled trial of acute care for elders (ACE) in a community hospital. *J Am Geriatr Soc* 2000;48:1572–81.
12 Krumholz HM. Post-hospital syndrome--an acquired, transient condition of generalized risk. *N Engl J Med* 2013;368:100–2.
13 Cheng J, Montalto M, Leff B. Hospital at home. *Clin Geriatr Med* 2009;25:79–91.
14 pp.Levine DM, Ouchi K, Blanchfield B, *et al*. Hospital-Level care at home for acutely ill adults: a pilot randomized controlled trial. *J Gen Intern Med* 2018;33:729–36.
15 Levine DM, Ouchi K, Blanchfield B, *et al*. Hospital-Level care at home for acutely ill adults: a randomized controlled trial. *Ann Intern Med* 2020;172:77–85.
16 Leff B, Burton L, Mader SL, *et al*. Hospital at home: feasibility and outcomes of a program to provide hospital-level care at home for acutely ill older patients. *Ann Intern Med* 2005;143:798–808.
17 Cryer L, Shannon SB, Van Amsterdam M, *et al*. Costs for 'hospital at home' patients were 19 percent lower, with equal or better outcomes compared to similar inpatients. *Health Aff* 2012;31:1237–43.
18 Federman AD, Soones T, DeCherrie LV, *et al*. Association of a bundled Hospital-at-Home and 30-day Postacute transitional care program with clinical outcomes and patient experiences. *JAMA Intern Med* 2018;178:1033.
19 Levine DM, Desai MP, Ross J, *et al*. Rural perceptions of acute care at home: a qualitative analysis. *J Rural Health* 2021. doi:10.1111/jrh.12551. [Epub ahead of print: 13 Jan 2021].
20 Curry L, Nunez-Smith M. *Mixed methods in health science research: a practical primer*. SAGE Publications, 2015.
21 Creswell J. *Qualitative inquiry & research design: choosing among five approaches*. 3rd edn. SAGE Publications, 2013.
22 Levine DM, Pian J, Mahendrakumar K, *et al*. Hospital-Level care at home for acutely ill adults: a qualitative evaluation of a randomized controlled trial. *J Gen Intern Med* 2021. doi:10.1007/s11606-020-06416-7. [Epub ahead of print: 21 Jan 2021].
23 Bifulco P, Narducci F, Vertucci R, *et al*. Telemedicine supported by augmented reality: an interactive guide for untrained people in performing an ECG test. *Biomed Eng Online* 2014;13:153.
24 Waseh S, Dicker AP. Telemedicine training in undergraduate medical education: mixed-methods review. *JMIR Med Educ* 2019;5:e12515.
25 Dorsey ER, Topol EJ. State of telehealth. *N Engl J Med* 2016;375:154–61.
26 Gregg A, Tutek J, Leatherwood MD, *et al*. Systematic review of community Paramedicine and EMS mobile integrated health care interventions in the United States. *Popul Health Manag* 2019;22:213–22.
27 Choi BY, Blumberg C, Williams K. Mobile integrated health care and community Paramedicine: an emerging emergency medical services concept. *Ann Emerg Med* 2016;67:361–6.
28 Landon B, Loudon J, Selle M, *et al*. Factors influencing the retention and attrition of community health aides/practitioners in Alaska. *J Rural Health* 2004;20:221–30.
29 WHO. *10 facts on patient safety*, 2019.

BMJ Innov: first published as 10.1136/bmjinnov-2020-000592 on 24 February 2021. Downloaded from http://innovations.bmj.com/ on April 23, 2024 by guest. Protected by copyright.

Scoping and Testing Rural Acute Care at Home: A Simulation Analysis

David M Levine, MD MPH MA
Meghna P Desai, MPH
Joseph B Ross, MPA
Natalie Como, MD
Steve Holley, EMT-P

SUPPLEMENT

Sample landscape analysis
Rural Counties- Utah State County classification[a] (1)

County	**County Population Estimate (2017)** [b]	**% Pop in Poverty** [c]	**County health rankings** [d] (2)	**Utah Health Improvement Index** [e] (3)	**RUCA[f] (County)**	**Primary Care Clinics/Independent Providers** (4)	**Acute Care Hospital**	**Does Hospital provide Emergency Services ?**	**FAR[g] (Zip)**	**EMS Super Rural (Zip)[h]**
Uintah	35,150	11.66	Health outcomes: 24; Health factors: 26	Average HII (101.46)	8,5,4	Basic Medical Clinic 84078; Valley Family Clinic 84078	Ashley Regional Medical Center, 84078	Yes	2	Yes
							Uintah Basin Medical Center (partnership with Intermountain), 84066	Yes	2	Yes
Summit	41,106	8.41	Health outcomes:2 Health factors: 2	Low HII (88.67)	10,7,4,2	Coalville Health Center 84017;Kamas Health Center 84036; UUHC Redstone Health Center 84098	Park City Hospital (Intermountain) 84060	Yes	0	Yes
Wasatch	32,106;	8.22	Health outcomes: 2; Health factor: 6	Low HII 90.67	4	Wasatch Medical Clinic 84032, Intermountain Heber Valley Clinic 84032; several independent providers	Heber Valley Hospital (CAH), 84032	Yes	0	Yes
							Utah Valley Hospital, 84604	Yes	0	No
Carbon	20,295	14.13	Health outcomes: 27; Health Factors: 20	High HII-109.61	4,5	Several private PCP providers; The Family Clinic 84501; Castle Country Family Medicine 84501; Carbon Medical	Castleview Hospital, 84501	Yes	2	Yes

						Service Association 84520; Helper Clinic 84526				

Note: Counties listed are examples and do not necessarily represent where mock admissions were performed

[a] County classifications: Frontier (6 or fewer persons per square mile); Rural (more than 6 but less than 100 persons per square mile); Urban (100 or more persons per square mile)

[b] U.S Census Bureau Estimates, 2017

[c] U.S Census Bureau Estimates, 2017

[d] County health rankings-Health outcomes: the overall rankings in health outcomes represent how healthy counties are within the state, the healthiest county in the state is ranked #1. The ranks are based on two types of measures: how long people live and how healthy people feel while alive; Health Factors: the overall rankings in health factors represent what influences the health of a county. They are an estimate of the future health of counties as compared to other counties within a state. The ranks are based on four types of measures: health behaviors, clinical care, social and economic, and physical environment factors.

[e] The Utah Health Improvement Index (HII): Developed by the Utah Department of Health, the HII is a composite measure of social determinants of health by geographic area. The higher the index, the more improvement the area needs

[f] Rural-urban commuting code area codes

[g] Frontier and remote area codes

[h] Centers for Medicare & Medicaid Services (CMS) ambulance fee schedule

Mock admission cases

Case 1. Male in his 70s with HF notes weight gain and new dyspnea on exertion over last 2 weeks. He notes significant dietary indiscretion leading up to his weight gain. He has tried following his doctor's instructions to double his furosemide, but he continues gaining weight and becoming more breathless. He has a new 4 pillow orthopnea. No chest pain, cough, fevers, chills, nausea, vomiting, or diarrhea.

Case 2. Female in her 80s with COPD notes shortness of breath, newly increased sputum production, and worsening cough for the past 4 days. She notes a preceding upper respiratory tract infection obtained likely from her spouse. She struggles with making it from her living room to her kitchen due to shortness of breath. Her sputum remains clear. No chest pain, fevers, chills, nausea, vomiting, or diarrhea.

Clinician post-discharge interview guide

1. Please share with me your experience during the home hospital admission. Walk me through from admission to discharge.

    Admission:

        Probe: What went smoothly? What could have gone better?

        Probe: What would you adjust or change?

        Probe: How could we improve logistics for home hospital deployment?

    Daily rounds:

        Probe: What went smoothly? What could have gone better?

        Probe: What would you adjust or change?

        Probe: How could we improve logistics for daily rounds?

    Discharge:

        Probe: What went smoothly? What could have gone better?

        Probe: What would you adjust or change?

        Probe: How could we improve logistics for home hospital discharge?

        Probe: What surprises were there during your home hospital admission? Can you talk a little about those?

        Probe: Discuss how easy or hard it was to work with other members of the team. Why was that?

        Probe: How hard was it to use the technology?

2. If this had been a real admission, would care have been delivered effectively and safely? Why or why not?

Probe: What were the biggest challenges to providing care to a home hospital patient?

Probe: How could you have done it differently?

Probe: How well were you able to deliver the care you wanted remotely? Did you have any concerns about patient safety – if so, please describe.

Probe: Did you have challenges with equipment malfunction, communications, connectivity at any point during the home hospital process? If so, please describe what happened and how it was resolved.

Probe: What sort of technologies or capabilities would make you more effective?

5. What did you like best about providing care through home hospital?

Probe: How did you feel your relationship with the patient and their caregiver(s) differed in the home hospital setting vs. typical inpatient care?

Probe: How did you feel about traveling to/from the patient's home?

6. In your opinion, was the patient's and caregiver(s) experience optimal in the home hospital setting? Why or why not?

7. After your experience with this mock admission, what sort of training or support do you think would be helpful for clinicians providing home hospital in rural areas?

8. Is there anything else you think we should know about your home hospital experience?

Patient and Caregiver post-discharge interview guide

1. Please share with me your experience during the home hospital admission. Walk me through from admission to discharge.

    Let's start with the admission process:
    - Probe: What went smoothly? What could have gone better?
    - Probe: What would you adjust or change about the admission process?
    - Probe: *(challenges/difficulties)* How could the home hospital team have made the admission process better for you?
    - Probe: How comfortable were you during your admission, physically and emotionally? How did it feel to have a care team in your home?

    Let's talk about your home hospital stay after admission, including check-ins with your care team:
    - Probe: (Both patients and caregivers): How did you feel about your relationship with your clinician while in the home hospital? How did this relationship differ (if at all) from being in the hospital?
    - Probe: How comfortable were you during your admission? How did it feel to have a care team in your home? What could the team have done to be more sensitive to your home?
    - Probe: (Both patients and caregivers): How did you feel about the daily rounds with your clinician being done at home? What about 'on-call' visits or phone calls? What did you like or not like about these check-ins being done at home?
    - Probe: How did it feel to be monitored in your home? Were you comfortable? Why or why not? Any concerns about monitoring (i.e. the equipment malfunctioned)?
    - Probe: How hard was it to use the technology the team brought?

    Let's talk about the discharge process:
    - Probe: What went smoothly? What could have gone better?
    - Probe: What would you adjust or change about the discharge process?
    - Probe: *(challenges/difficulties)* How could the home hospital team have made the discharge process better for you?
    - Probe: How did it feel to be discharged directly to your home? What did you like about it? What didn't you like?

2. In general, how did you feel about receiving hospital care in your home?
    - Probe: How do you feel getting care in your home compares to the regular hospital?
    - Probe: What is your comfort level with receiving care remotely?
    - Probe: What was the quality of care like?
    - Probe (For patients): How safe did you feel receiving hospital care in your home? Why did you feel safe or unsafe?

Probe (For caregivers): How comfortable did you feel about your family member being cared for at home? How safe did you feel your family member was in home hospital?

3. For the patient who has a caregiver: How do you think the person who takes care of you would be affected by your home hospitalization?

Probe: (*more/less burdened)* How could we improve that?

4. What were the benefits to being hospitalized at home? What were the challenges?

5. What other improvements would you make to home hospital?

6. If you were to ever be hospitalized in the future, would you choose home hospital or regular hospital? Why?

7. Is there anything else you think we should know about your home hospital experience

References

1.Utah Department of Health O of PC and RH. Utah Primary Care Needs Assessment 2018 [Internet]. Utah Department of Health; 2018 [cited 2019 Mar 11]. Available from: https://ruralhealth.health.utah.gov/workforce-development/primary-care-office-pco/primary-care-needs-assessment/

2. Givens M, Jovaag A, Van Dijk JW. 2018 Utah State Report [Internet]. University of Wisconsin-Madison School of Medicine and Public Health Department of Population Health Sciences Population Health Institute; 2018 [cited 2019 Mar 10]. Available from: http://www.countyhealthrankings.org/explore-health-rankings/reports/state-reports/2018/utah

3. Diez D, Friedrichs M. The Utah Health Improvement Index [Internet]. Utah Department of Health; 2018 [cited 2019 Mar 11]. Available from: https://health.utah.gov/disparities/data/ohd/UtahHII.pdf

4.Find a Provider or clinic [Internet]. [cited 2019 Apr 18]. Available from: http://www.health.utah.gov/pcn/find.html