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A TRANSDISCIPLINARY STRATEGIC APPROACH TO IMPLEMENTING AN EFFECTIVE HOSPITAL-AT-HOME FRAMEWORK

Authored by

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ABSTRACT

The rise in the incidence of global pandemics and climate catastrophes demonstrates that the demand for healthcare services is stretched beyond what services can be effectively provided. Even with increased healthcare spending in recent years in the United States and worldwide, access to healthcare resources has declined for many. To improve the quality and accessibility of healthcare solutions to meet this increasing demand and increase patient self-efficacy, connected healthcare solutions, including hospital-at-home, are being introduced. Many limitations exist for hospital-at-home models, including policy gaps, technological gaps, and issues patients face specific to their health outcomes. To overcome these limitations, a transdisciplinary framework for hospital-at-home is presented in this white paper. Barriers to the implementation of this framework are discussed, including healthcare worker burnout and the impact on the social determinants of health. Potential extensions to the transdisciplinary framework beyond hospital at home are also presented.

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1. INTRODUCTION

The recent global pandemic (COVID-19 emergency), climate catastrophes (hurricanes, fires, volcano eruptions, and earthquakes), war and civil turmoil, and urgent situations, including mass shootings, mental health impacts, and long-term care, have demonstrated that the demands on healthcare networks are stretched beyond what services can timely, safely, and effectively provide. Nevertheless, "first do no harm" remains a sacred obligation for all in healthcare, and success requires "constancy of purpose for improvement."

In the United States, spending on healthcare reached nearly 20% of gross domestic product (GDP) in 2020. At the same time, fewer people have access to resources that allow them to maintain their health and wellness and prevent health problems such as hospital-acquired infections. Life expectancy has declined significantly in the United States when compared with other OECD countries, and the vast percentage who died in the United States from COVID-19 in 2020 were over 65 years old (81%), in hospitals (66.2%), in nursing homes or long-term care (24.3%), and at home (4.7%). Many relied on others for information and care. Other indicators illustrate the crisis of U.S. healthcare infrastructure and delivery system; they include but are not limited to rising maternal mortality and morbidity, fetal and infant mortality and morbidity, mental health, suicide, violence, and abuse, and penetrating wounds including gunfire and stabbings, sepsis, substance-related health problems and deaths, and more.

Connected healthcare, including hospital-at-home (HAH), can improve healthcare access. For example, HAH can reduce risks associated with congregant housing and increase the quality of life for many without requiring a person to leave the support of their family and community to receive care and alleviate their suffering. While various HAH initiatives have demonstrated benefits, there remain significant obstacles. A new and bold transdisciplinary strategic approach is needed to reach beyond the status quo of today's access and healthcare—that is, to go from silos, to move to extend beyond evolutionary to revolutionary sustainable, equitable inclusion, and access to healthcare and well-being for each member of society for lifelong well-being. Without diversity, equity, accessibility, and inclusion, these systems will continue to pose risks to marginalized, minority, indigenous, underrepresented, disabled, culturally, and linguistically diverse people.

In addition, many elements are needed for HAH to be effective, including social, government, regulatory, professional, logistic, and technological factors. Well-designed and human factors sound technology supported by forward-looking standards can provide a framework and a practical vision of the future for inclusion and accessibility in HAH. The team seeks a framework that facilitates assessing, conceiving, and deploying hospital-at-home models to pursue a comprehensive strategy. This actionable framework offers guidance to agencies,

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countries, and private sector manufacturers, suppliers, and distributors in expediting the implementation of secure, safe, and equitable international standards for home-based care.

The first HAH program was established in 1995 at Johns Hopkins. HAH provides acute critical care to patients at home and reduces unnecessary hospitalization and related complications. If the HAH option were unavailable, the patient would be admitted to a hospital ward. The identified patients for this model of care are elderly patients with chronic conditions and multiple comorbidities. While variable, the organizational structures of hospital-at-home models share common foundational elements. The hospital-at-home approach is particularly suited for patients with moderate acuity, whose clinical conditions warrant medical team-level care but are deemed stable enough for vigilant home-based monitoring with occasional outpatient check-in as needed.

At its simplest, the HAH model represents a paradigm shift in healthcare delivery, wherein healthcare professionals provide active treatment to patients within/close to their residences for conditions that would conventionally necessitate hospitalization. Typically, these initiatives encompass collaborative care teams delivering a comprehensive range of services after early discharge or post-emergency room visits, all without requiring inpatient hospital care. Such services can encompass home infusion, remote monitoring, laboratory testing, and home visits by various medical and social professionals, including nurses, physicians, nurse practitioners, social workers, physiotherapists, and pharmacists.

2. NEED FOR HOSPITAL-AT-HOME

The transition toward hospital-grade care at home is driven by multiple strategic and logistic imperatives that extend beyond its prospective cost-cutting impact. Primarily, it offers a promising avenue for broadening healthcare access, a particularly crucial pursuit in regions where medical facilities and traditional hospital setups remain scarce. In addition, this paradigm tackles a pivotal concern: enhancing the patient's experience and agency, goals both healthcare institutions and caregivers ardently seek to attain. Finally, in light of the global shortage of healthcare practitioners, HAH provides technological interventions like remote monitoring devices that can facilitate the delivery of secure and high-caliber care with reduced reliance on professional staffing.

Different services are provided under different HAH models, modalities, and programs. These comprise combinations of services related to diagnostics, monitoring, and treatment, support services, and integration services. Examples include the following:

- Diagnostics at the remote point of care, such as tele-ultrasound.

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- Monitoring, including healthcare professional visits and monitoring of vital signs and parameters with biosensors, wearables, skin patches, and other devices.
- Treatment, including administration of medications, medication management and reconciliation, digital platform support, and therapist visits.
- Mental health diagnostics and anxiety mitigation biofeedback systems.
- Support services, such as patient education and emergencies.
- Integration services, integrating the institutional with the personal digital health ecosystem.
- Communication services, including messaging reminders, capturing PROMs, etc.
- Data mining services, including using AI, e.g., for identifying potential candidates for early discharge to the HAH.

In the United States, during COVID-19, the Centers for Medicare & Medicaid Services (CMS) launched the Acute Hospital Care at Home (AHCaH) initiative to allow Medicare-certified hospitals to treat patients with inpatient-level care at home. In less than a year, as of October 27, 2021, 186 hospitals in 82 health systems across 33 states had implemented AHCaH and treated 1878 patients. The development of the program was informed by extensive consultation with both academic and private-sector industry leaders to ensure appropriate safeguards were in place to protect patients and for providers submitting hospital admission waiver requests, including, for example, adequate support with information technology and back-end triage capabilities to review, approve, or deny waiver requests. In cases where hospital capacity was at or over 100%, patients in the waiver program could receive high-quality, hospital-level care in their homes, which decreased their exposure risks to COVID-19 and helped limit the consequences of overburdened providers in local hospitals. This was demonstrated effectively and safely in Italy when, due to COVID-19, hospitals were above capacity, and sick patients were treated at home safely.

Fostering data-sharing mechanisms to fortify patient care quality and safety to help advance hospital at home (HAH) implementation in the United States and other nations is urgently needed. Key recommendations for enhancing HAH implementation are given in Table 1.

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TABLE 1 Recommendations for enhancing HAH implementation

Recommendation	Description
Standardization of Data Collection	Create a uniform data collection structure for consistent benchmarking, to enable participation, data-coupled technology, and collaboration and to deliver meaningful and usable evidence, incorporating patient and caregiver-reported experiences and outcomes for responsive care.
Transparent Data Monitoring	Regularly monitor and openly report data to evaluate the effectiveness, appropriateness, and safety of HAH models and tools.
Repository of Care Pathways	Develop a repository of context-specific HAH care pathways, aiding regions new to implementation with validated models and robust tools.
Local Capacity Surveillance	Establish mechanisms for resource allocation and surveillance of local capacity to deliver HAH care during emergencies or crises.
Global Knowledge Sharing	Build evidence-based hubs to share successful practices and challenges globally, fostering informed, transparent, and equitable decision-making.

3. CURRENT LIMITATIONS OF HOSPITAL-AT-HOME MODELS

3.1. HEALTHCARE ECOSYSTEM GAPS

Although there are many benefits and advantages, the HAH model of care has significant barriers and limitations, such as reimbursement for payment, physician and patient resistance, patient safety, and a lack of quantifying research data to support the use of this model.

Many safety concerns need to be addressed and taken care of in the HAH model of care. One of the leading concerns is medication management. Polypharmacy and inappropriate medications are significant factors causing medication errors or drug therapy problems in approximately 70% of home care patients, especially patients with chronic conditions.

Other medication safety issues include errors in dosing, confusion regarding medication orders and names, and poor medication compliance. Treatment at home is also challenged with infection control. The patient's age, the complexity of the illness, and the condition of the living environment together play a role in the transmission of infection. Patients receiving invasive interventions, such as catheter insertion, hemodialysis, or intravenous lines, are also exposed to an increased risk of infection at home.

One of the growing safety concerns in a home setting is the risk of falls. Increased events of falls in elderly individuals in the home setting led to increased healthcare costs. In 2014, the Medicare expenses related to falls

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had exceeded U.S. $31 billion, causing it to become the leading cause of accidental injury and death in older patients. Patients receiving home care are frequently subject to malnutrition due to food preparation and selection challenges. This causes various problems, such as gastrointestinal, cardiac, and respiratory problems, and other medical issues leading to frequent readmissions.

3.2. ISSUES PATIENTS FACE THAT TECHNOLOGY CAN ADDRESS IN HAH SETTINGS

Patient outcomes that should be addressed in HAH settings include (1) mortality and quality of life; (2) transfer or readmission to the hospital; (3) patient-reported and clinical outcomes; (4) patient satisfaction; (5) length of stay; and (6) cost. Technology deployed in HAH settings can significantly improve these outcomes.

The 2016 Cochrane review study assessed cost-benefit improvements when providing healthcare in an HAH setting. It indicated little improvement in patient health outcomes or the cost of care relative to inpatient care. Another study, expanding the model to specifically cover post-discharge services to reduce unplanned readmissions and improve quality of life and patient satisfaction (including predischarge, post-discharge interventions, and bridging the transition) similarly demonstrated that HAH discharge management models that sought to reduce unplanned readmissions and avoidable healthcare costs as the core goal were generally not successful in achieving it. Instead, models where the goal was to improve multiple aspects of the transition care process, such as improving continuity of care and patient status, reducing errors and near-miss events, and improving the subsequent utilization of primary care, resulted in overall reductions in unplanned readmissions. Early discharge is considered part of post-discharge HAH services. This suggests a multidisciplinary, multifaceted, and contextually appropriate approach is required, setting HAH-driven healthcare improvements as a goal in the context of integrated care. Interestingly, reported benefits excluded care coordination.

The best results seem to come from digitalizing the post-discharge phase, including improved post-discharge planning, communication with primary care, medication reconciliation, patient education, clinician continuity, follow-up scheduling, rehabilitation services or home visits, telephone follow-up, or telemonitoring. Virtual wards in populations with nonspecific complex diseases showed no impact on mortality, readmissions, or costs. Disease-specific virtual wards effectively reduce complications and all-cause mortality; however, readmissions may not be lower as they could further occur due to better early detection of complications. Overall, the models reviewed demonstrated improvements in patient satisfaction with care, self-efficacy, confidence with coping with their condition, and reduced patient and carer anxiety despite not seeing reductions in hospital

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readmissions. Models that sought to improve communication between hospital and primary care resulted in improved general practitioner satisfaction with the transition process.

In addition, transitions between home, ambulance transfers, and clinic or hospital admissions are locally optimized. With a transdisciplinary strategic approach and standards, the infrastructures that can support transitions across locations, contexts, and applications will meet the needs of patients and carers in an HAH model. An important example is the need for individuals to have access to reliable power and communications even during an environmental emergency and to know when power or communications might be interrupted and for how long. Standards are needed to improve data transparency for HAH models to manage connectivity and power, privacy, and security, even when people are in their homes, without requiring all citizens to become communications and information technology (CIT) specialists. Also, new developments in health informatics, including digital health and participatory health informatics (PHI), may impact HAH approaches.

Intelligent communication and power management network interface units could improve the knowledge, skills, and attitudes of HAH users, having better information about the risks to the infrastructure and predict when patients must be transported to a hospital to avoid catastrophic loss of power and communications or impact of weather and emergency that would isolate them from additional services needed in a distributed network. In addition, having a network interface unit managing all the resources within a person's home requires significant new security to protect privacy and avoid unwanted predatory behavior.

Another example is the transition of services between HAH, through an ambulance, and to a clinic or hospital. An optimistic view of HAH would improve the information available for the transition hand-offs among physical locations and service provider contexts. When an ambulance is called to a house, the network infrastructure could be admitted to HAH and related information to inform paramedics and emergency medical technicians about all the vital information and needs of the ill person they will encounter in the home. In an ideal situation, even before the ambulance is dispatched, the patient's needs will be anticipated, the correct staff and equipment dispatched, and simultaneous destination locations can be identified where appropriate resources are available, including an appropriate hospital bed and appropriate level of clinical expertise.

A critical challenge that must be addressed by HAH patients and HAH staff and for any digital health interventions with access to patient records is medication reconciliation and administration at home and during transitions to and from the HAH.

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3.3. TECHNOLOGICAL GAPS

3.3.1. COMMUNICATION INFRASTRUCTURE CAPABILITIES FOR HAH

Network infrastructure and features have transitioned over time, and various new models have become available, including over-the-top (OTT), voice-over-internet protocol (VoIP), and a variety of offerings from cable, satellite, terrestrial providers, aggregators, and specialty services providers. This technology ecosystem is complex and many steps away from the end designers of healthcare, for example, HAH. Importantly, these services do not provide lifeline services; many are mere best-effort services. In the case of HAH, many people need to be served, the services are vulnerable to outages and interruptions, and few adjudicating processes address the needs of people in their homes to ensure reliable and available healthcare infrastructure.

3.3.2. OPTIMAL, EFFICIENT, AND TIMELY INFORMATION EXCHANGE FOR HAH

Managing transitions among homes, ambulances, hospitals, and service providers with an advanced communication network and features for emergency services could improve and tightly couple the properties often referred to as social determinants of health (SDOH), cultural and linguistic appropriate services (CLAS-HHS), addressing United Nations Sustainable Development Goals (UN SDGs), incorporating accessibility and accommodation for disabling conditions including but not limited to hearing and vision loss, cognitive, mobility, identity, privacy, and more. Often, these are seen as somebody else's responsibility or not at all part of healthcare. They are very complex and daunting and require many skills not often represented in healthcare settings. Only through a transdisciplinary and multijurisdictional strategic approach can these diverse constituencies and requirements be represented in an agile model built upon a strong foundation of standardized technology for the future.

3.3.3. ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING IN THE HAH

Artificial intelligence and machine learning (AI/ML) are tools that hold great potential. There is an extraordinary expansion in research and applications of AI/ML, robotics, extended reality (XR), and media globally, with significant potential impact on healthcare. Although researchers and engineers have used AI/ML for many years, its increased employment in recent years in areas like medical decision-making, image recognition, large language models (LLM), and other applications and toolkits have elevated the discussion about its potential and

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