Defining Value in Population Health: Evaluating Program Impact and Outcomes
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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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***Abstract*— The University of Virginia (UVA) Health's Population Health Department advances health equity by expanding access to patient-centered care and improving health outcomes. One of their programs, Interactive Home Monitoring (IHM), provides follow-up care for patients discharged from the UVA Medical Center through remote patient monitoring protocols, proactive care coordination strategies, and patient engagement practices. This paper aims to inform quality improvement for IHM by understanding the value of the program through currently collected metrics (e.g. readmissions, emergency department visits, length of stay) and through creating a more holistic understanding of value from multiple stakeholder perspectives. Defining and demonstrating the value of IHM is currently challenging due to the ambiguous nature of value and limitations in data collection and reporting, including data integration and capturing patient perspectives. This paper evaluates IHM's effectiveness using statistical methods to compare outcomes between enrolled patients and those eligible but not enrolled. This addresses the challenges posed by limited data collection and reporting in defining and demonstrating program value. Through qualitative content analysis of interview notes and Mann-Whitney tests of datasets on the Locus platform, we define value for IHM. The findings aim to establish a framework for defining and assessing value in population health programs, aligning stakeholder priorities with program outcomes. This analysis provides actionable insights to enhance program effectiveness and measure value and could be used as a framework for similar population health programs.**

Keywords—population health, healthcare, value

I. Introduction

Population health programs embedded in larger health systems play a role in improving health outcomes for targeted populations by implementing data-driven and community-oriented strategies [1, 2]. As healthcare shifts toward patient-centered care, bridging clinical and home settings is essential to tailoring care plans and improving adherence [3, 4]. Hirsch & Blomquist note that to be effective, and therefore secure sustainable funding, population health programs must address one or more risk factors (i.e. physical activity, social connections, financial strain), sustain those changes over time, and remain feasible for communities [5]. Yet, demonstrating value is challenging due to data limitations, a lack of standardized evaluation frameworks, and the complexity of defining value [6, 7].

While evaluation frameworks may provide avenues for structured assessment, the very concept of value remains difficult to define and measure. Part of this challenge arises from the lack of an established, universally agreed-upon framework for conceptualizing and operationalizing value in population health programs [7]. Value may be conceptualized differently depending on a program's goals and the populations it serves, shaping whether success is measured by cost savings, healthcare utilization, or improvements in social determinants of health (SDOH) [7]. Community well-being has a ripple effect on individual health, reinforcing the need to assess both clinical and social outcomes [8]. Given this complexity, locally grounded definitions of value are necessary, alongside a standardized yet adaptable evaluation framework.

Given the challenge of universally defining value, structured evaluation frameworks offer different approaches to measuring program success. Chan et al. note that currently, at least 57 population health evaluation frameworks exist, varying in scope and emphasis [8]. They explain that some focus on traditional health metrics, such as hospital readmission rates, morbidity, and cost-effectiveness, while others integrate broader determinants like housing stability and food security. Notably, 50 frameworks explicitly include SDOH, reflecting growing recognition of their role in shaping health outcomes [8].

Frameworks that exclude SDOH primarily assess clinical and financial impact, whereas those incorporating SDOH provide a more holistic perspective. Because SDOH are often underrepresented in traditional measures of value, this analysis focuses on them as a component of program evaluation.

University of Virginia (UVA) Health's Population Health Department is committed to advancing health equity by expanding access to patient-centered care and improving health outcomes. This paper evaluates their Interactive Home Monitoring (IHM) program, which supports patients after discharge from the UVA Medical Center through remote monitoring, proactive care coordination, and patient engagement. IHM aims to reduce readmissions and non-critical emergency visits, but it faces challenges in demonstrating value due to difficulty defining value and data collection limitations. Issues such as self-reported inaccuracies, missing data, and difficulties in interpreting free-text data complicate evaluation. Additionally, IHM's transition from Locus Health to Compass Rose, a part of Epic's Population Health software, for data collection has made trend analysis difficult, which parallels challenges seen across health systems [6]. This paper aims to inform quality improvement efforts by developing a locally grounded conceptualization of value for IHM. This paper will also assess the program's impact on SDOH risk assessments, hospital readmissions, emergency department visits, and length of stay (LOS) while designing a framework for future evaluations of IHM.

II. METHODS

A. Overview

This study aimed to conceptualize and assess the value of IHM by analyzing current metrics and exploring stakeholder perceptions of value. The research process began with a literature review on population health program evaluation frameworks and the definition of value. Discussions with program directors and stakeholders helped establish UVA Health's current conceptualization of value and align on program objectives. Insights from program directors ensured that this analysis provided meaningful contributions by integrating existing evaluations of IHM. A walkthrough of historical and current data collection systems with the IHM director facilitated familiarity with the data and its complexities. The IHM director also helped define the stakeholders to be included in developing a locally grounded understanding of value.

This quality improvement study employed a concurrent mixed-methods approach. Qualitative data were collected through interviews with health professionals, the program director, and patients to capture differing perspectives on value. Quantitative data were obtained from UVA Health's Locus Health Platform, encompassing both IHM-enrolled patients and eligible non-enrolled patients, to assess differences in outcome measures including readmission rates, ED visits, and average LOS. Readmissions are defined as unplanned inpatient admissions, where the patient is admitted to the Medical Center within 30 days of the discharge date of the prior admission. Number of ED visits counts the number of times a patient is admitted into the emergency department, and length of stay is defined as the number of days a patient is in the hospital for an inpatient or readmission visit. All required approvals and consent procedures were followed in accordance with UVA Health's quality improvement project guidelines. The team iteratively analyzed both data types, and the quantitative data was presented to stakeholders to refine the analysis and maintain alignment with program goals, ultimately guiding the assessment of IHM's value.

B. Analysis of IHM Data from Locus Health

Four de-identified datasets covering IHM patients from July 1, 2023 to June 30, 2024 were obtained from UVA Health. These datasets contained 8 to 39 variables and 291 to 38,551 observations. The patient information dataset included variables such as unique identifiers, age range, gender, hospital readmission risk, and enrollment dates. The SDOH dataset included all SDOH screenings for each patient from 2014 - 2025. The metrics dataset provided monthly readmissions, ED visits, and LOS, while the task dataset contained recorded health professional activities, such as "Follow-up - Week 2," "PHQ Task," and "Appointment Task." The patient information and metrics datasets included one observation per patient, while the SDOH and task datasets contained multiple observations per patient. These metrics were selected based on literature review findings and discussions with program directors as indicators of IHM program value. Data for non-enrolled IHM-eligible patients were also obtained, though no task dataset was available since these activities only occur with IHM patients.

Initial review of the data focused on quality assessment. Validations of patterns, clarifications on data recording methods, and variable significance were obtained through consultations with the IHM program director. For example, null values in SDOH screenings indicated that a given domain had not been assessed. Additionally, inconsistencies in task logging rendered the task dataset inadequate for assessing specific interventions, shifting the analysis toward overall program value.

Descriptive statistics were used on gender distribution and risk level, the likelihood of a patient experiencing an adverse event or negative health outcome, to ensure comparability between IHM and non-IHM patient groups. Comparative statistical analyses were then conducted to examine differences in the outcomes of interest between IHM and non-IHM patients, examining overall differences. These included Mann-Whitney tests and t-tests. Microsoft Excel, R, and Minitab were used for this analysis.

C. Health Professional, Director, and Patient Interviews

Semi-structured interviews were conducted with health professionals, patients, and the IHM director to understand the value of the program from multiple perspectives. To ensure confidentiality, interviews were not recorded, and two team members took notes during each session. The program director invited nine health professionals to participate. Three physicians, two nursing professionals, one pharmacist, and two case managers agreed to be interviewed. Each interview lasted 30 to 40 minutes and was conducted via Zoom or phone. Health professionals were asked about the patient population served by IHM, their perceptions on how IHM provides value, and potential areas of improvement. The IHM program director was also interviewed via Zoom for 40 minutes about his perception

of IHM's value as well as how the success of the program is currently determined. To capture patient perspectives on IHM's value, six patients were randomly selected by program administrators. Case managers facilitated contact, obtained verbal consent, and introduced patients to the research team. Each patient interview lasted 10 to 15 minutes and was conducted via phone. No patient identifiers were collected. Patients were asked about their experience with IHM and how it has impacted their lives.

Conventional content analysis was employed using Dedoose, deriving coding categories directly from the data without predefined theories [9]. Two team members independently reviewed interview notes, developing codes and themes based on recurring insights. These themes were iteratively refined with input from other team members and the senior author. The final coding framework emphasized themes that appeared at least five times across interviews, a threshold chosen to ensure that included themes reflected perspectives shared by multiple participants. This approach helped systematically represent the most recurring ideas across our 14 interviews.

III. RESULTS

A. Analysis of Population Health Data

In order to quantify the validity of comparing the two sample populations utilized in this analysis, we compared the makeup of the datasets in terms of risk level and gender. The proportion of patients in each risk category (Very High, High, Medium, or Low) differed by no more than 5.2% between the groups. The proportion of patients that were female and male differed by no more than 4.9%. We found that these differences were small enough to validate the comparison of IHM and non-IHM patients for the quantitative study.

Fig. 1 visualizes the difference in the percentage of patients who did not return to the hospital after their initial SDOH screening between IHM patients and comparable non-IHM patients. According to the analysis, 4.05% of IHM patients were SDOH screened in the hospital after being discharged from the program, meaning they went back to the hospital at least once after program enrollment, compared to 6.11% of non-IHM comparable patients. The reason for rehospitalization is not specified in the data set.

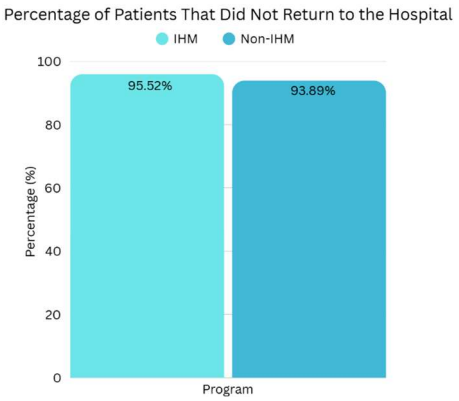

Fig. 1. Percentage of Patients That Did Not Return to the Hospital

Table 1 shows the comparison of average readmissions, lengths of stay, and ED visits between IHM and non-IHM comparable patients. IHM patients were readmitted nearly half the number of times as non-IHM patients were, with their average readmissions having a statistically significant difference using a Mann-Whitney test ($p = 0.023$) at the 0.05 significance level. Similarly, there was a statistically significant difference in the average ED visits per patient for IHM and non-IHM patients using a Mann-Whitney test ($p = 0.00$) at the 0.05 significance level. After program enrollment, 95% of patients had zero readmissions and 77% of patients had zero ED visits. Lastly, there was a statistically significant difference between the average LOS for IHM and non-IHM patients using a Mann-Whitney test ($p = 0.040$) at the 0.05 significance level. IHM patients had an average LOS 0.29 days shorter than the comparable non-IHM patients.

TABLE I. Outcome Measures for IHM and Non-IHM Patients

	Outcome Measures		
	Readmissions	***LOS***	***ED Visits***
IHM Average	0.062	5.28	0.42
Non-IHM Average	0.125	5.57	0.85

Fig. 2 displays the percentage of flags for SDOH domains among IHM patients across FY24. Each percentage represents the average of all SDOH flags per month that fall under a specific domain. The distribution remains relatively stable over time, with Physical Activity and Social Connections consistently comprising the largest share of total flags. However, based on input from the program director, the domains of most concern for reducing readmissions were Transportation, Food, Depression, Stress, Housing, and Utilities. In contrast, Social Connections and Physical Activity, despite having the highest flagging rates, were identified as lower priorities within the program.

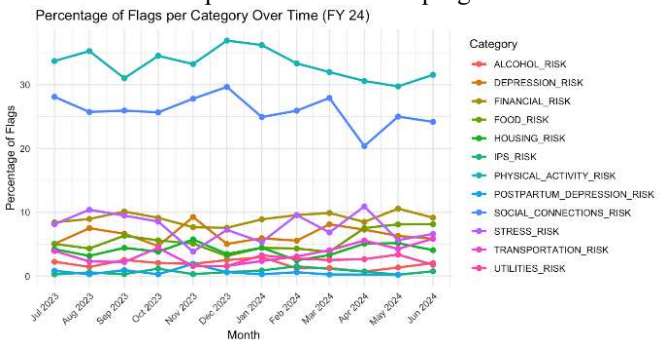

Fig. 2. Percentage of Flags for SDOH Domains for IHM Patients over FY24

Fig. 3 visualizes the average of readmissions, ED visits, and LOS when a SDOH domain is flagged for an IHM patient in FY24. Food and Housing risk have the highest average readmissions of 0.17. Interpersonal Safety (IPS) and Housing risk have the highest average ED visits of 1.20 and 1.04, respectively. Lastly, Utilities and Depression risk have the

highest average LOS of 6.09 and 5.94 days, respectively. Despite having the highest proportion of flags, Physical Activity and Social Connections risk ranked in the lower half of SDOH domains for average readmissions, ED visits, and LOS, never ranking higher than 7th out of 12, where 1st indicates the highest average readmissions.

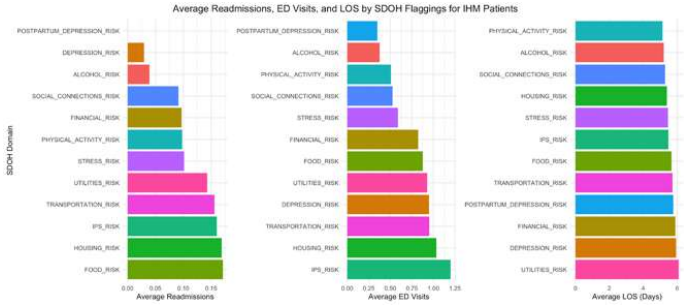

Fig. 3. Average Readmissions, ED Visits, and LOS by SDOH Flaggings

B. Analysis of Interview Data

IHM is relevant to three primary stakeholders: patients, health professionals, and UVA Health at the health system level. In the analysis of the interview data, four primary aspects of value emerged. These are organized as a systems framework in Fig. 4, and number of times each aspect of value was mentioned in the interviews is displayed in Fig. 5. For the UVA Health System, value was defined as a reduction in hospital readmissions. For patients, value also stemmed from a reduction in hospital readmissions, as well as from the emotional support provided by IHM. Patients highlighted that the care they received from IHM enabled them to avoid returning to the hospital, and they noted feeling cared for and seen. For health professionals, value was defined in the context of patients through IHM's role in providing emotional support, building health literacy and confidence, and connecting patients to resources, which includes helping patients access resources that address SDOH needs, obtain transportation to appointments, and schedule appointments. These different understandings of value reflect the multidimensional nature of the program's impact and shape how each stakeholder experiences its benefits and challenges.

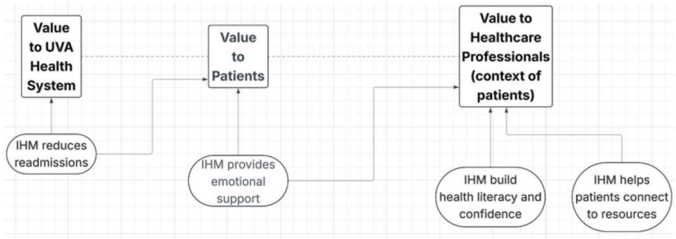

Fig. 4. Systems Framework of Value

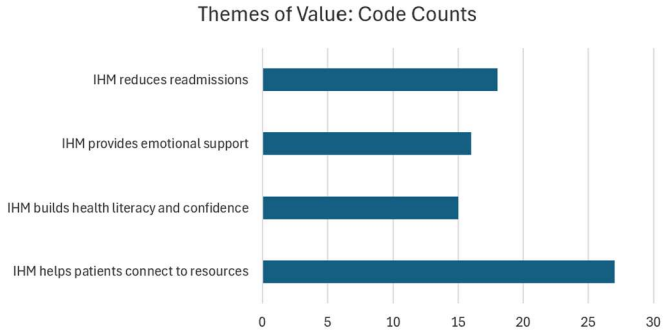

Fig. 5. Occurrences of Themes of Value

Beyond these definitions of value, the interviews revealed key processes that either contribute to or detract from value for each stakeholder. These are organized as a systems framework in Fig. 6, and the number of times each process was mentioned is displayed in Fig. 7. For patients, value was enhanced by means of the continuous monitoring provided, which includes phone call check-ins and remote vital signs monitoring, and detracted from due to a lack of awareness about IHM, with some patients saying they were initially unaware they were enrolled in the program at all. For health professionals, value was enhanced when IHM staff communicated effectively with each other, and detracted from when there was a lack of communication between health professionals and a lack of health professional awareness of the program. Some health professionals noted they were unclear on what responsibilities other team members held and the full range of services IHM offers. In the context of patients, health professionals expressed that providing continuous monitoring added value to patients, and technology barriers experienced by patients detracted from value to patients. From the health system's perspective, while reduced readmissions are a clear benefit, value was diminished by the absence of formal methods to quantify the program's impact and the lack of personal patient feedback mechanisms. These limitations make it more difficult for UVA Health to measure success and guide program improvements.

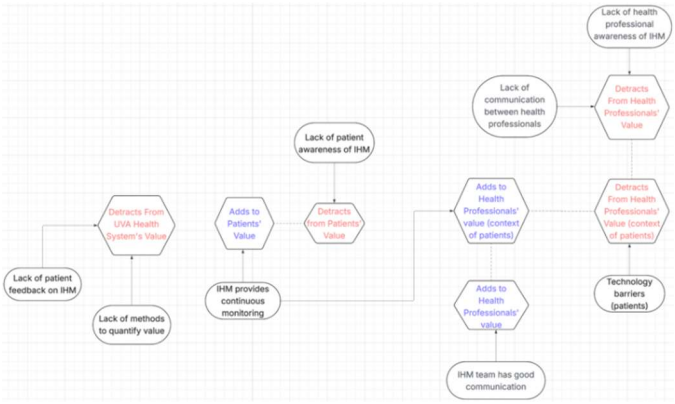

Fig. 6. Systems Framework of What Adds and Detracts Value

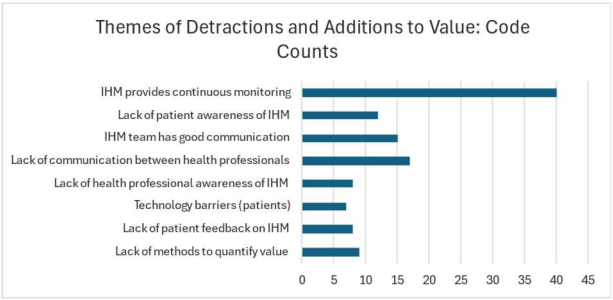

Fig. 7. Occurrences of Themes of Detractions and Additions to Value

To identify which elements of the program are driving success in outcomes like reduced readmissions, which is valuable to patients and UVA Health, the director of IHM called out the importance of also tracking intermediate process metrics such as appointment no-shows, case mix index (CMI) scores, schedule compliance, medication adherence, insurance utilization, and Primary Care Provider (PCP) compliance.

IV. Discussion

A. Comparison to Previous Research

Existing literature on population health program evaluation is sparse, largely due to the absence of standardized measurement frameworks. The frameworks that do exist often focus on processes that are assumed to generate value, rather than exploring how different stakeholders define value. Our findings build on this literature by illustrating how stakeholders conceptualize value in distinct and sometimes overlapping ways. As noted by Adams and Neville, value may be conceptualized differently by each stakeholder, so these differences must be defined when evaluating health programs [7]. This aligns with our findings that stakeholders define the value of IHM in different ways. For instance, while health professionals view connecting patients to resources as valuable to patients, this was hardly mentioned by patients themselves.

Additionally, this research builds upon previous studies on continuity of care. Pereira Gray et al. found in their systematic review that increased continuity of care is strongly associated with reduced mortality, demonstrating the clinical significance of continuous patient-provider interactions beyond patient preference alone [10]. In this study, it was found that IHM provides value through continuous monitoring which is a part of continuity of care. In our study, it was not mortality that was reduced due to participation in the program, but rather readmissions. These findings extend the existing literature on continuity of care.

Our findings confirmed readmissions as a metric for population health programs, as found by Chan et al. [8]. They also found that some programs use SDOH screenings as an evaluation tool, which coincides with our study. Our study also reinforces prior findings about the practical challenges of program evaluation related to data quality. Existing literature highlights the difficulty in evaluating health programs due to issues with data accuracy, completeness, and usability [6]. Our study contributes to this point by demonstrating the practical limitations of evaluating a population health program when such issues are present.

B. Implications

Based on the results of our quality improvement project, there are not enough appropriate metrics nor data to properly assess and communicate the value of IHM to UVA health professionals and administrators. Readmissions is a metric recognized as valuable both because it is consistently tracked and because stakeholders perceive it as an important indicator of value. However, there are more aspects of the program that are perceived as valuable but are not tracked by current metrics, including patient emotional support, continuous monitoring of patients, and patient health literacy. To close this gap, data collection should include the following metrics: personal patient feedback, emotional support, continuous monitoring adherence rate (% of IHM-enrolled patients with vitals successfully monitored daily/weekly), patient perceived safety from monitoring, and a health literacy confidence score. Due to the director IHM calling out the importance of also tracking intermediate process metrics such as appointment no-shows, case mix index (CMI) scores, schedule compliance, medication adherence, insurance utilization, and Primary Care Provider (PCP) compliance, they should also be tracked. These can provide insight into where interventions are having the most impact and where future efforts should be focused. Continuous monitoring adherence rate and the metrics suggested by the director can be tracked via the existing Compass Rose data collections software, and the rest of the metrics can be collected via an exit survey during the IHM Completion Call task that currently takes place at program completion. Additionally, while value was demonstrated through reducing readmissions, ED visits, and average LOS, to further reduce these metrics, health professionals can target food, housing, IPS, utilities, and depression as they were the highest-risk domains across these metrics. This new way of assessing value should be visualized and shared amongst health professionals through a data dashboard and reviewed by team members through regular checkpoints. This approach to assessing the value of IHM was developed considering the specific services that IHM provides but could be generalized to other population health programs. It involves identifying what data are currently being collected and assessing value based on those metrics, while also trying to understand additional dimensions that should be captured to provide a more comprehensive understanding of value.

C. Limitations

The main limitation faced by our team was data incompleteness and inaccuracy. We were given one program enrollment date per IHM patient even if the patient enrolled in the program more than once due to complications with retrieving data in a timely and ethical manner. Also, a lack of a uniform way of entering interventions performed by health professionals resulted in missing or inaccurate data. Additionally, only the phone call check-ins themselves were tracked, providing no insight into intervention details.

Ideally, a more robust statistical analysis would include comparing patients between the two groups and a pre- and post-test of readmissions, ED visits, and LOS metrics; however, we were lacking pre-enrollment data. Similarly, these metrics were

only calculated for IHM patients after enrollment and through FY24, meaning some patients had more months of metrics recorded than others, possibly skewing the results. Ideally, readmissions, ED visits, and LOS would be tracked for 365 days pre-program enrollment and 365 days post program enrollment.

Regarding interview data, there was a limited sample size of interviewees (n=15), and unequal ratios of doctors, nurses, pharmacists and case managers. There was also selection bias in who was interviewed, as participants had to consent to be interviewed, and the health professionals interviewed were asked by the program director.

D. Future Work

To standardize how value is assessed across institutions with similar programs, future research could focus on developing a shared framework for measuring value in community health programs. A similar mixed-methods study, like the one we conducted for UVA Health, could be expanded into a multi-site and multi-program study to develop a more generalizable framework for assessing both value and the processes that shape value. Then, to communicate value, a range of stakeholders could co-design effective visualizations.

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