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Evaluation of a Novel Community-based Chronic Disease Management Solution

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NanoHealth
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EXECUTIVE SUMMARY 3
1. BACKGROUND 4
2. ABOUT NANOHEALTH 4
2.1 Community Health Workers (Saathis) 5
2.2 Continuous training of Saathis 5
2.2.1 Performance management of Saathis 6
2.3 Empanelment of doctors 6
2.4 Integrated proprietary technology platform 6
2.5 NanoHealth's Services 7
2.5.1 Health Screening (Case Finding) at the doorstep 7
2.5.2 Case Management 8
3. PERFORMANCE EVALUATION 9
3.1 Health Impact Indicators 9
3.1.1 Case Finding 10
3.1.2 Case Management 12
3.2 Operational Feasibility of the Model 14
3.2.1 User acquisition on plan 14
3.2.2 User retention on plan after enrollment 15
3.2.3 Saathis' Productivity 16
3.3 Financial Sustainability 18
3.3.1 Conversion ratio (second screen to enrollment) and retention required to be profitable 19
3.3.2 Number of users required per Saathi to be profitable 19
4. CONCLUSION AND DISCUSSION 20
5. REFERENCES 22

EXECUTIVE SUMMARY

According to WHO, 39.5 million of 56.4 million global deaths in 2015 were due to non-communicable diseases (NCDs) such as cardiovascular diseases, cancers, diabetes, and chronic lung diseases. In India, NCDs account for 61% of the morbidity and mortality and is rising disproportionately in the low-income segments. Current health systems (both public and private) are designed primarily to address episodic/acute complications arising out of these conditions rather than managing these conditions over the long term to avoid such complications. The need for the hour is for interventions that can support in improving the diagnosis and management of NCDs.

In this report, we critically evaluated a social enterprise model (*NanoHealth*) that leverages a unique combination of community health workers called "Saathis" and a proprietary technology platform to facilitate early diagnosis and continuous management of chronic NCDs such as Diabetes and Hypertension. In particular, we investigated NanoHealth's impact on health outcomes of its users by analyzing the operational and financial feasibility of its model using its operational data between March 2015 and March 2017.

We found that NanoHealth was successful in identifying undiagnosed and undertreated population at risk of developing diabetes, hypertension, or its complications. Twenty eight percent of the screened individuals were at risk of developing diabetes or its complications; 21% of whom had no previous history / knowledge about the disease. Fifty nine percent of the screened individuals were at risk for developing hypertension or its complications; 65% of whom had no previous history/ knowledge of the disease. Individuals, who enrolled on the NanoHealth plan and continued it for 12 months, experienced a significant decrease in fasting blood glucose (20.1mg/dL) and systolic blood pressure (9.2mmHg) compared to their baseline values. However, we found that significant improvements were needed both on acquisition and retention of customers to make the model financially sustainable; only 6.78% of the screened population was enrolled on the plan and of those, 57% users remained on the plan after 12 months.

Our findings lead to two levels of recommendations to improve the acquisition and retention of the users and achieve financial sustainability of the model. At an operational level, given that cost of community health workers is mostly fixed, NanoHealth should aim to improve their productivity (number of visits per day) and to appropriately allocate their capacity over initial screening and monthly monitoring visits. At a strategic level, public payers that internalize the cost of poorly controlled NCDs (e.g., CGHS and ESIS) should partner with NanoHealth and procure its services for their beneficiaries. Finally, state governments should consider integrating the proposed NCD programs under the National Health Policy 2017 with community-based models such as NanoHealth.

1. BACKGROUND

Chronic non-communicable diseases (NCDs) such as diabetes, cancer, cardiovascular diseases, and stroke account for 61% deaths in India and an annual loss of 5-10% of GDP in India due to loss in productivity.[1-3] NCDs account for 235 million disability-adjusted life years (DALYs) in India compared to 222 million DALYs accounted by communicable diseases, and this is rapidly increasing.[4] The economic and health burden of NCDs is expected to increase due to the growth in the older population.

Effective NCD management hinges critically on overcoming twin barriers of untimely diagnosis and fragmented and episodic care. First, NCDs are often characterized by a long asymptomatic phase during which patients' motivation to seek a diagnosis is low. It is estimated that 30-60% Indians living with diabetes and 25-40% living with hypertension are undiagnosed of their condition, missing the opportunity for timely care.[5-7] Second, there is often no cure for NCDs and sustained intervention (clinical as well as behavioral) is required for limiting the adverse their effects on patient health. Lack of continuous care management results in poor prescription compliance, absence of regular checkups and loss in opportunity for early identification of any potential comorbidities and complications that may develop. Globally, medication adherence of patients with NCDs is only around 50%[8] and conjectured to be even lower in developing countries for a variety of socioeconomic and cultural factors.

Non-communicable diseases are emerging in both rural and urban areas, most prominently in people living in low income urban settings.[9] Prevalence rates of diabetes increased by 135% in the last 10 years in low-income groups compared to 24% increase in the middle-income groups in urban India.[10-12] The urban poor faces the compulsion to reach out to nearby informal healthcare providers of questionable credentials due to lack of access (both geographical and fiscal) to better qualified providers and thus end up utilizing poor quality but easily accessible health services.[13] In addition, as most Indians are uninsured, there is no central regulatory authority for health services. The National Health Policy of India (2017) has recognized the need for effective NCD management and has set a goal to establish "controlled disease status" for 80% of known diabetic and hypertensive population by 2025.[14] However, this goal is not backed up by the requisite level of public funding. For instance, the recently launched National Health Protection Scheme[15] covers hospitalization expenses up to INR 500,000 per family leaving outpatient disease management efforts largely to be financed by out-of-pocket expenses.[16] The government spends almost half its resources on in-patient beds for NCDs.[17] Consequently, patients are likely to continue underinvesting in these efforts resulting in high healthcare utilization and hospitalization costs in the long term. To compound challenges, private healthcare sector in India is highly fragmented, operates predominantly on a fee-for-service model and, consequently, does not have the incentives to undertake active management of chronic NCDs at a population level and control these costs.

Social enterprises that marry public health vision with private sector focus on financial sustainability are ideally suited to address these market failures bridging the gap between providers and end-users.[18] In this report, we undertake a detailed operational evaluation of one such social enterprise model and draw implications for the wider ecosystem and the challenge of NCD management at a national level.

2. ABOUT NANOHEALTH

NanoHealth provides proactive and continuous care for management of NCDs to low income families in the city of Hyderabad. It was founded in 2014 after the founders won the prestigious Hult Prize.[19] In the last three years, NanoHealth has touched over 70,000 people and actively manages health of over 2000 users. NanoHealth operates in urban slums and their surrounding neighborhoods. The catchment population comprises individuals working as drivers, daily wage earners, domestic helpers, vendors

and self-employed professionals in the unorganized sector of the economy. The average family income of its beneficiaries ranges between INR 15,000—INR 30,000 per month. Most people inhabit *pucca*[1] houses with electricity and water supplies. Figure 1 indicates various active locations of NanoHealth.

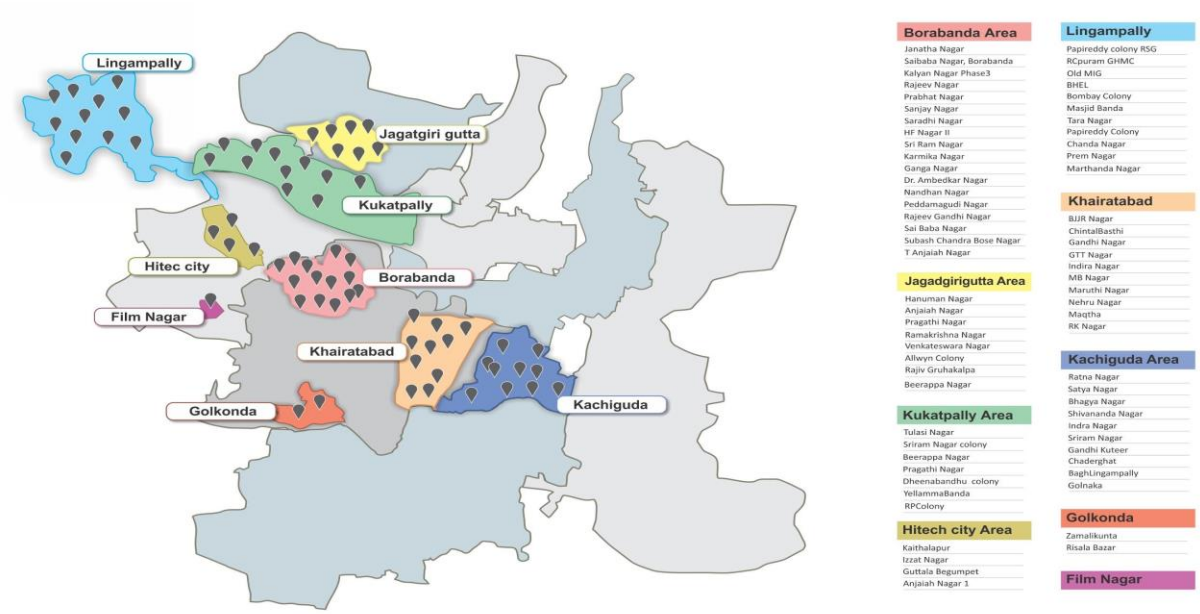

Figure 1: Active NanoHealth Locations in Hyderabad (This map is for indicative purpose only, and is not set to scale)

NanoHealth aims to improve the diagnosis and management of NCDs through: (i) trained and certified community health workers known as *Saathis* (meaning 'companions' in Hindi) and (ii) an integrated proprietary technology platform.

2.1 Community Health Workers (Saathis)

Saathis (“companions” in Hindi) are trusted women members of the community with at least secondary school education who are interested in welfare services. Saathis are selected through community referrals and typically serve the community that they come from. A recruitment test is conducted to assess their basic knowledge on health, basic reasoning, communication skills and behavioral skills. Upon recruitment, they are trained and certified by NanoHealth. Each Saathi covers an area having population of around 5000 and performs a range of clinical, behavioral and operational tasks to achieve the goal of managing the health of the users in her catchment area.

2.2 Continuous training of Saathis

Saathis undergo a rigorous training by the NanoHealth training team led by a clinician on patient care management, use of the Saathi application, operational protocols and behavioral protocols. They are trained to assess for clinical presentation and risk factors, education of users, principles of management, record keeping, and referral scheme for users with hypertension and/or diabetes. Training methods include formal lectures, demonstration, discussions, practical sessions, role playing, post-training evaluation and continuous training sessions known as refresher trainings.

[1] Pucca houses refer to dwellings that are designed to be solid and permanent in their construction

2.2.1 Performance management of Saathis

NanoHealth uses a combination of financial (e.g. incentives) and non-financial methods (e.g. recognition) to ensure performance of the Saathis. Saathis performance is measured on two key aspects: operational efficiency (number of follow-up visits conducted per month) and clinical outcomes of the user.

Operational Efficiency: A web-based dashboard displays multiple live indicators of Saathis' operational performance in real time. These include number of patient touches, number of repeat user visits per month, number of new enrolments. Dashboard and reports are scrutinized regularly by field executives, each of whom monitors maximum of ten Saathis.

Clinical Performance Monitoring: The Saathis are evaluated based on the movement of their respective users from high risk categories to low risk categories over a period of time. This would depend on the nature of follow up and counselling provided to the users.

2.3 Empanelment of doctors

NanoHealth applies stringent evaluation criteria before empaneling the doctors in their network. These include some key aspects such as reviewing the qualification of the doctor including their certifications; checking the reputation of the doctors within the community through informal interviews with key community members; making physical visits to the clinic to assess the approachability and hygiene of the premises and finally ensuring acceptability of the doctors to agree on the guidelines laid out by NanoHealth like prescription of generic medicine, avoid unnecessary diagnostic tests etc.

2.4 Integrated proprietary technology platform

The technology platform supports the Saathis in delivering personalized care services at scale. These include health screening, doctor consultation, diagnostics, and medication through the following modules:

Saathi Module: Each Saathi is provided with a Doc-in-a-Bag™, that contains point-of-care diagnostic devices and a tablet-based module that assists them to perform doorstep, health screening, inform users about their risk-profile, deliver appropriate counselling, manage work schedules to meet the required targets, and coordinate appointments with doctors and other providers for the users. In case a user does not own a smartphone, Saathis can use this module to book an appointment with the appropriate service providers (e.g. doctor, nutritionists, lab technician) and also help them with video consultation.

User Module: The user module (mobile & Web) provides information to individuals about their own health and facilitates effective self-management of the disease. Users can access their electronic health records (EHRs), view analytics on their health indicators, and follow associated recommendations (e.g. repeat doctor visits, medication reminders). They can use the app to, interact with doctors and health coaches, take video consultation with doctors/nutritionists, book diagnostic tests at the labs and order drugs from pharmacies.

Provider Module: The provider module is a customized interface created for each of the multiple providers such as general physicians, specialists, diagnostic providers, and dieticians that manage health of the users. This application allows for seamless information sharing on user health profile across provider network. For example, the doctor web application assists doctors in seeing EHRs

(electronic health records), entering e-prescriptions during physical or virtual consultation, and to communicate with Saathis.

2.5 NanoHealth's Services

NanoHealth undertakes various activities to enable early identification of individuals who are at risk for NCDs and to provide convenient and continuous care for managing NCDs over the long-term. Figure 2 below describes the broad contours of the operational model of NanoHealth.

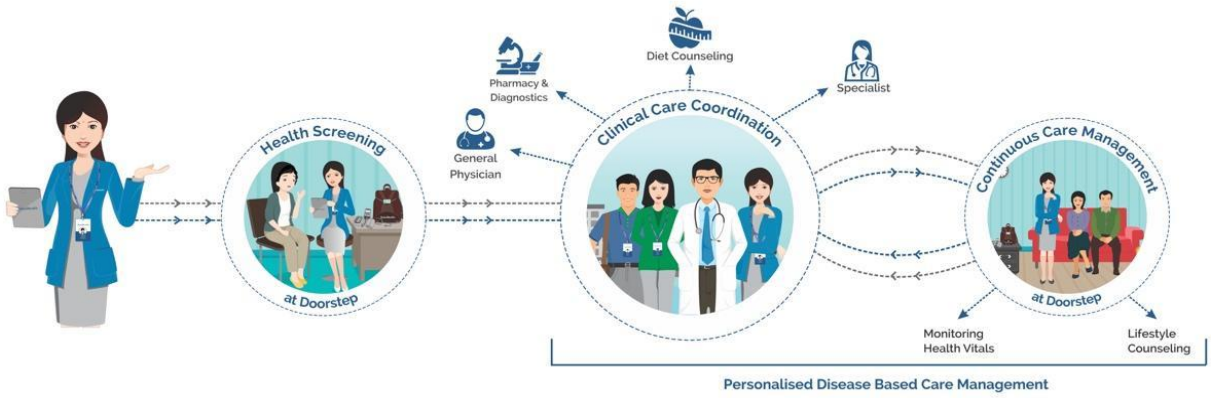

Figure 2: NanoHealth Operational Model

2.5.1 Health Screening (Case Finding) at the doorstep

Saathis screen population in their community to identify users at risk of diabetes, hypertension, and obesity through door-to-door surveys and camps. Each Saathi is equipped with a point-of-care diagnostic kit called Doc-in-a-Bag™ that includes a tablet-based module- Saathi Module. Saathis use this Doc-in-a-Bag™ to measure users' health parameters (anthropometric and blood sugar) and enter this data directly into the tablet. During screening, data is also collected on various other parameters such as demographics, previous medical, family medical history, and chief complaints (e.g. dizziness, dry tongue, nocturia, heartache, numbness and/or tingling sensation in limbs). NanoHealth's proprietary inbuilt algorithm uses this data and stratify users into High and Low Risk for Hypertension, Diabetes & Obesity. This aids Saathis in making various levels of on-spot recommendations such as referrals to doctors, change of diet plans etc. and accordingly an appropriate disease management plan is recommended to the users. A simple algorithm is also used to color code[2] values entered for each parameter that help Saathis to easily understand the extent of severity for various diseases. A brief description of the color levels used is indicated below in Figure 3:

Black	Readings are extremely high; E.g. Blood pressure > 180/110
Red	Readings are above acceptable clinical range; E.g. Blood Pressure > 140/90
Yellow	Readings are above recommended normal range but below clinical diagnostic levels; E.g. Blood Pressure > 120/80
Green	Readings are within recommended normal ranges; E.g. blood pressure < 120/80

Figure 3: Color coded output on tablet used by Saathis

[2] Color coding is not an indicators of an absolute risk profile of users.

The technology platform helps in keeping track of timelines for next planned activities, personalized for each screened user. High-risk users undergo a second screening. In the seconds screening, fasting blood glucose and additional readings of blood pressure are measured for cases at high risk of diabetes and hypertension respectively. Once they are found to be at high risk again during the second screening, they are counselled and referred to a doctor within the NanoHealth empaneled network, or partner government health centers for confirmation of diagnosis and treatment. High risk users who receive a confirmed diagnosis from the doctor are encouraged to enroll into *NanoHealth Plan*. The core services of the plan are then made accessible to interested users at a single, all-inclusive price at the time of enrollment and successive monthly subscription. At risk users are counselled for necessary diet and lifestyle modifications to prevent the onset of chronic conditions. They are counselled to get a quarterly screening to monitor progress. Low-risk users are advised to enroll for periodic (bi-annual) screenings.

2.5.2 Case Management

Clinical Care Coordination: NanoHealth's Saathis guide the user to the appropriate healthcare provider(s) at regular intervals. The NanoHealth provider network has registered and certified providers who are connected through technology (provider apps) to ensure coordinated care to users.

Continuous Care Management at doorstep: Saathis act as a health coach to support the users in disease management. They make periodic follow-up visits to the user's household to monitor and measure their health parameters, perform standard screening assessments based on user care plan (e.g. diabetic foot examination), ensure diet and medication compliance, and facilitate referral to the provider network if and when required. Users are provided a diet and medicine compliance calendar that records the user's adherence to diet and medication on a monthly basis. They also counsel users, in local language, to manage and control lifestyle-related risk factors such as obesity, tobacco consumption, physical inactivity, and unhealthy diet. All health education sessions are conducted privately by Saathis with each enrolled user along with a family member. Figure 4 depicts the clinical workflow which provides an alternative conceptualization of the NanoHealth model.

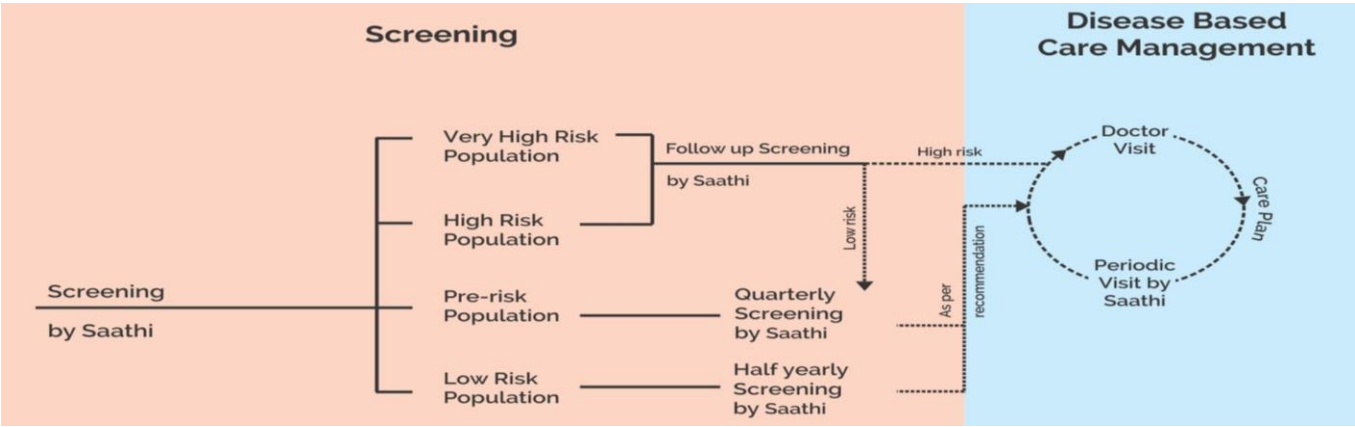

Figure 4:NanoHealth Clinical Workflow

3. PERFORMANCE EVALUATION

Our evaluation framework and the metrics therein (Table 1) are informed by NanoHealth's public health mission and its modus operandi as a social enterprise. Since the fundamental objective of the program is to address the rising burden of NCDs, assessing the effectiveness of program in screening of undiagnosed population (for diabetes and/or hypertension), monitoring, and improving the health of the users enrolled to the program is critical. As a social enterprise, it is important for NanoHealth to establish operational scalability and financial sustainability which are intricately linked. We undertook our analysis using NanoHealth's operational data for various timelines as mentioned in the Table 1.

Table 1: Evaluation Metrics

Health Impact (Using data from March 2015- June 2017)	**Operational Feasibility of Model** (Using data from August 2015-July 2016; July 2017- June 2017)
Case Finding ● Percent users without any previous medical history detected, from screening activities, at risk of having diabetes and hypertension; undiagnosed cases ● Percent of users with previous medical history of diabetes/hypertension detected, from screening activities, at risk of having diabetes and hypertension complications; undertreated cases *Case Management* ● Decrease in fasting blood glucose from baseline to end line ● Decrease in blood pressure from baseline to end line ● Change in the proportion of users with controlled fasting blood glucose and blood pressure from baseline to end line	*User acquisition* ● Conversion rate of users from first screen to enrollment *User retention* ● Percentage of users who retained on the plan in three-month interval (3,6,12) post enrollment ● Months for which users stayed enrolled on the plan (median) *Saathi's productivity* ● Home visits (average, median, range) done per Saathi per month ● Days between two consecutive home visits for enrolled users *Financial Sustainability* ● Average new enrollment per Saathi per month ● No. of users required per each Saathi to be profitable

3.1 Health Impact Indicators

We measured the effectiveness of the program in improving health of the users by its ability of (i) Case Finding- find undiagnosed and undertreated cases by its screening activities, and (ii) Case Management- improved and controlled health measurements (blood glucose and blood pressure) among enrolled users.

Users were classified as hypertensive if their systolic blood pressure (SBP) was ≥140mmHg and diastolic blood pressure (DBP) ≥90mmHg or were taking blood pressure lowering medications.[20] Users

were classified as diabetic if their fasting blood glucose (FBG) was ≥126 mg /dl or were taking glucose lowering medications.[21-22]Users were classified as overweight if their BMI was between 25–29.9Kg/m2 and obese if their BMI was above 30Kg/m2. Abdominal obesity was defined as a waist circumference ≥90cm in men and ≥80cm in women.

3.1.1 Case Finding

A total of 43,794 users were screened by Saathis through door-to-door and camps from the period between March 2016- June 2017. Table 2 describes the health profile of screened users at baseline.[3]

The mean age of users screened was 41.8 years. Thirty seven percent (16,273) were men with mean age 43.1 years and 63% (27,521) were women with mean age 41.0 years. Majority (61%) of the users screened were either overweight or obese. Fifty nine percent (25,241) were found to have uncontrolled systolic blood pressure and hence at risk of developing hypertension or its complications; 28%(12,190) had uncontrolled fasting- or random blood glucose levels and hence at risk of developing diabetes or its complications.

[3] Number of users with or without previous medical history of diabetes and hypertension are not mutually exclusive.

Table 2: Baseline Health Profile of Screened Users

	Total Screened (N=43,794)	Total Screened with previous history of diabetes (N=5,388)	Total Screened without previous medical history of diabetes (N=38,406)	Total Screened with previous history of hypertension (N=8,083)	Total Screened without previous medical history of hypertension (N=35,711)
Age (yrs.), mean (SD)	41.8 (13.6)	53.1 (11.7)	40.2 (13.1)	53.8 (12.4)	39.0 (12.3)
BMI (kg/m^2), median (IQR)	24.3 (21.2,27.7)	25.8 (23.1,29.1)	24.1 (20.9,27.4)	26.1 (23.0,29.7)	23.9 (20.8,27.2)
Underweight (<18.5), N (%)	4,285 (10)	188 (4)	4,097 (11)	367 (5)	3,918 (11)
Normal (>=18.5-22.9), N (%)	12,385 (29)	1,067 (20)	11,323 (30)	1,570 (20)	10,815 (31)
Overweight (>=23-24.9), N (%)	6,813 (16)	905 (17)	5,908 (16)	1,1,83 (15)	5,630 (16)
Obese (>=25), N (%)	19,374 (45)	3,111 (59)	16,263 (43)	4,788 (60)	14,586 (42)
Waist Circumference [a]					
<90cms	17,205 (39)	1,360 (25)	15,845 (41)	1,990 (25)	15,215 (43)
>=90cms	26,589 (61)	4,028 (75)	22,561 (59)	6,093 (75)	20,496 (57)
Plasma Glucose Level					
Fasting glucose level, median (IQR)	112 (98,148)	151 (122,205)	105 (94,120)	-	-
<100mg/dL, N (%)	116 (28)	9 (6)	107 (39)	-	-
100-125mg/dL, N (%)	146 (35)	33 (23)	113 (41)	-	-
126mg/dL, N (%)	155 (37)	99 (70)	56 (20)	-	-
Random glucose level, median (IQR)	117 (100,143)	201 (143,279)	114 (98,134)	-	-
<140mg/dL, N (%)	31,418 (73)	1,216 (23)	30,202 (79)	-	-
140-199mg/dL, N (%)	7,605 (17)	1,323 (26)	6,251 (17)	-	-
200mg/dL, N (%)	4,284 (10)	2,673 (51)	1,611 (4)	-	-
Blood Pressure					
Systolic blood pressure, median (IQR)	123 (112,138)	-	-	140 (126,156)	121 (110,133)
<120mmHg, N (%)	17,860 (41)	-	-	1,205 (15)	16,655 (47)
120-139mmHg, N (%)	15,066 (35)	-	-	2,577 (33)	12,489 (36)
140mmHg, N (%)	10,175 (24)	-	-	4,146 (52)	6,029 (17)
Diastolic blood pressure, median (IQR)	82 (75,90)	-	-	89 (80,97)	81 (74,89)
<80mmHg, %	17,254 (41)	-	-	1,849 (24)	15,405 (44)
80-89mmHg, %	13,112 (31)	-	-	2,190 (28)	10,922 (32)
90mmHg (%)	12,121 (29)	-	-	3,756 (48)	8,365 (24)

SD=Standard Deviation, BMI=Body Mass Index, IQR=Interquartile Range,
[a] Waist circumference for women measured as <80cms &>=80cms

Of those who did not have previous history of diabetes, 21% were found to be at risk of diabetes (mean RBG was 122mg/dL, median=114, IQR=98,134 and FBG was 113mg/dL, median=105, IQR=94,120) and 65% were found to be at risk of hypertension (mean SBP as 132mmHg, median=121, IQR=110,133 and mean DBP was 88mg/dL, median=81, IQR=74, 89). These were the newly diagnosed users for developing diabetes/hypertension identified by Saathis. Further, 17% of those without any previous history were found to be prediabetic and 36% were found to be at risk of pre-hypertension were higher than those screened at risk of diabetes (4%) or hypertension (17%).

Of total screened, 12% (5,388) had previous medical history of diabetes and 18% (8,083) had previous medical history of hypertension. A significant fraction of users with previous medical history of diabetes/hypertension had uncontrolled measurements of fasting blood glucose≥126mg/dL (70%, mean=89, median=151, IQR=122,205) and blood pressure≥140/90mmHg (SBP=52%, mean=142, median=140, IQR=126,156), DBP=48%, mean=89, median=89, IQR=80,97). Users with previous medical history of diabetes/hypertension were older in age (53.1yrs/53.8yrs vs. 40.2yrs/39yrs) and had higher BMI (59%/60% vs. 43%/42%) and waist circumference (75%/75% vs. 59%/57%) as compared to those without any previous medical history.

The above findings highlight the prevalence of undiagnosed users with risk of having diabetes and hypertension among urban poor in India. It is also important to note that these findings indicate that NanoHealth screening program identified undiagnosed as well as undertreated population suffering from NCDs.

3.1.2 Case Management

To assess the health improvement in enrolled users, we included users who stayed on NanoHealth Plan for minimum 12 months post-enrollment between March 2015- June 2017 (n=384). Measurements recorded on/or before the day of enrollment were taken as baseline and those recorded on the 12 follow-up visits of enrolment were taken as end line. Paired t-test was done to evaluate the differences in averages of blood glucose levels, blood pressure, BMI, and waist circumference between pre- and post-implementation. Table 3 describes the change in blood glucose and anthropometric measurements from baseline to end line.

Table 3: Changes in health outcomes from baseline to end line at 12th month post-enrollment

	Baseline Values	**End Line Values**	**Difference in mean from baseline to end line**	***p value****
Plasma Glucose Level (mg/dL)				
Fasting blood glucose, mean (SD)	178.9 (75.2)	158.8 (67.5)	-20.1	<0.001
Blood Pressure (mmHg)				
Systolic blood pressure, mean (SD)	143.7 (23.0)	134.5 (16.7)	-9.2	<0.001
Diastolic blood pressure, mean (SD)	91.0 (12.7)	86.5 (9.6)	-4.5	<0.001
BMI (kg/m2), mean (SD)	26.3 (5.2)	26.3 (5.1)	-0.05	0.9
Waist circumference (cm), mean (SD)	36.6 (4.0)	36.3 (4.0)	-0.3	0.125

*p-values are from paired t-test of significance for mean

We found a significant decrease in fasting blood glucose by 20.1mg/dL and systolic blood pressure by 9.2mmHg compared to their baseline values after twelve months among users who stayed on the plan for 12 months. However, decrease in BMI and waist circumference was found to be insignificant among them. This could mean that there was limited change in lifestyle (dietary control or increased physical activity) among users. Perhaps, monthly home visits by Saathis could have caused a synergistic effect on adherence to medication that might have contributed to the decrease in the blood glucose and blood pressure.

Among diabetic users with previous history of diabetes, the decrease in fasting blood glucose was found to be higher (22.1mg/dL vs 12.4mg/dL) than who did not have previous history of diabetes before enrolling to the NanoHealth Plan (data not shown). Similarly, among hypertensive users with previous history of hypertension, the decrease in diastolic blood pressure was found to be higher (5.5mmHg vs 4.2mmHg) than those who did not had previous history of hypertension (data not shown). However, the decrease in systolic blood pressure was similar in users with and without previous history of hypertension.

In addition to measuring the average change in the blood glucose, blood pressure, and anthropometric measurements, we also checked the change in the proportion of users with controlled diabetes and hypertension at the 12th month from baseline. Figure 5 describes the change in percentage of users with improved health parameters after 12th follow-up visit from baseline.[4]

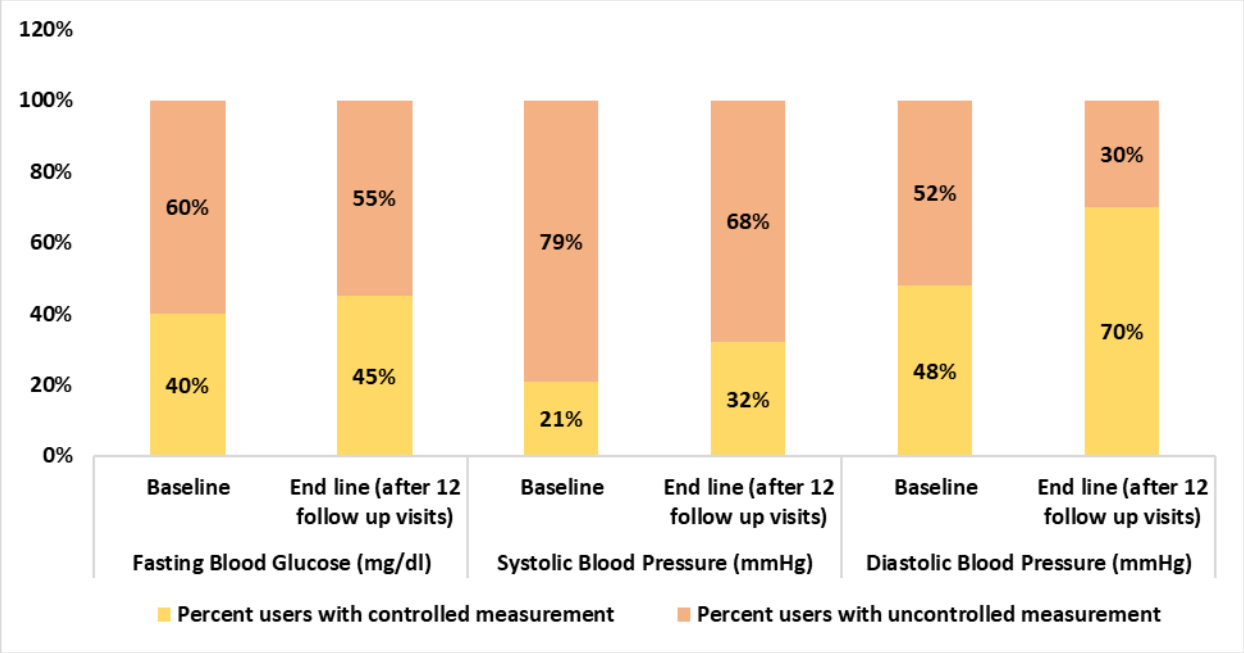

Figure 5: Percent users with change in health parameters before and after the intervention (March 2015-17)

Overall, we found an improvement in health of the users who enrolled on the plan. A significant decrease in the fasting blood glucose and blood pressure was observed in enrolled users after 4

[4] Users measured for blood glucose control include only diabetic & comorbid users (diabetic and hypertensive). Similarly, users measured for blood pressure control include hypertensive users with comorbid users (hypertensive and diabetic).

months of enrollment. Also, the proportion of users with controlled health measurements (FBG/BP) increased proportionally to the user's length of stay on the plan.

3.2 Operational Feasibility of the Model

We focused our evaluation to determine the feasibility of the model by measuring: user acquisition and user retention. Both these indicators are direct determinants of the model's financial sustainability, which in turn, depend on the level productivity of the Saathis and their ability to fulfil the defined goals. For our analysis, we used data collected by Saathis using tablets from July 2016 to June 2017.

3.2.1 User acquisition on plan

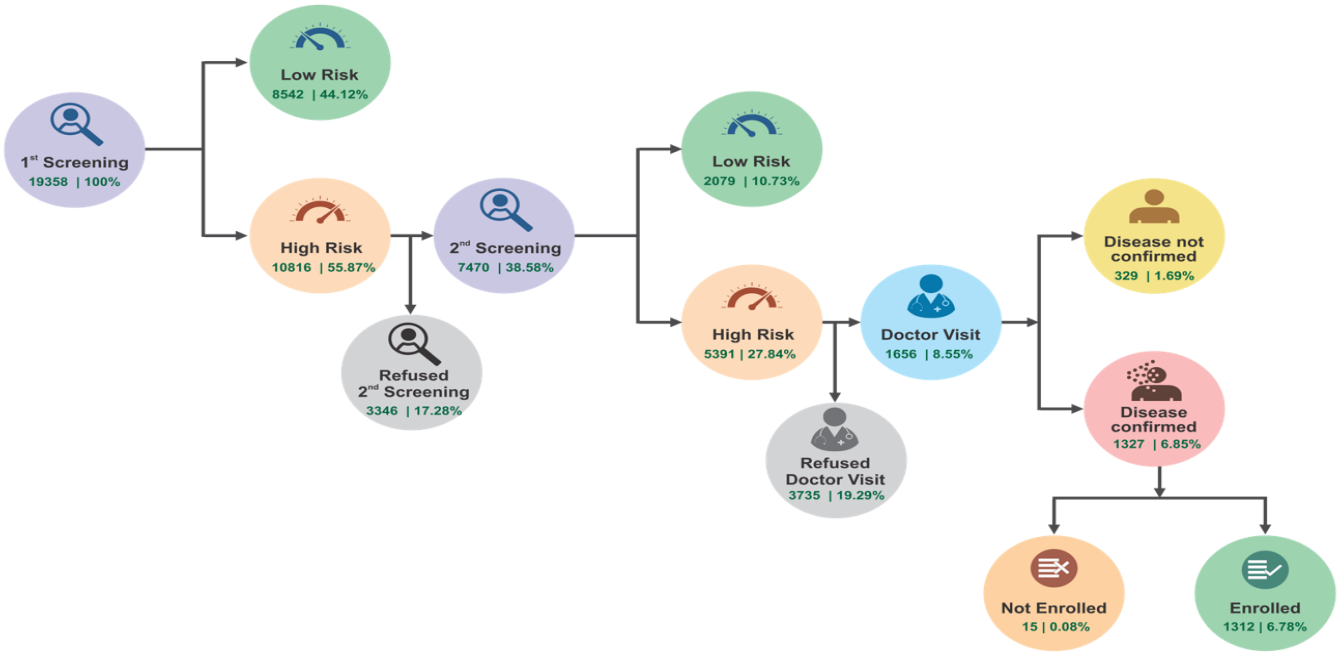

Figure 6: Number of users at various steps of enrollment process (July 2016 - June 2017). All percentages are with respect to number of users who underwent first screening.

A total of 19,388 users were screened from the period between July 2016 and June 2017. Thirty-one percent of the screened users were men with mean age of 46 years and 69% were women with mean age of 42 years. Figure 6 describes the cascade of user flow from first screening to enrollment.

As seen from the above cascade, one-fourth of the users were found to be at low risk in first screening. More than one-third (38.5%) of the population screened at high risk could not undergo second screening. One of the main reason for this is that the first screening usually happened in camp setting, and it is difficult to track the people again. These people were labelled as "untraceable".[5] Some percentage of the population refused second screening out of disinterest to pursue this further

Overall of the total users screened, only 6% finally enrolled into the NanoHealth Plan. In order to understand the factors that determine user's enrollment into the plan, we ran chi-square test to compare the distribution of determining categorical variables (age, gender, previous medical history,

[5] The untraceable participants are grouped together with participants who refused for second screening in Figure 8.

etc.) between users who enrolled and refused to enroll into the plan. We found that users were more likely to enroll on the plan if they had previous medical history of hypertension, had visited doctor for disease confirmation, or were followed up by Saathis within 3 days after risk confirmation (data not shown). A majority of the people screened at high risk refused to visit the doctor. One of the main reasons for this is the lack of awareness and urgency of managing the conditions at an early stage.

As can be observed from the above findings, the maximum visits conducted by each Saathi are first screen visits. Therefore, it is suggested that skimming of population should be done before first screening to increase the potential to find high-risk population and those that are likely to enroll. Some parameters such as age and gender groups may be useful before undertaking screening. Publicly available government data, for e.g. electoral poll or population survey data can help Saathis to prioritize the household. In addition, the findings state that almost 11% of the population was identified to be at low risk after the second screening, which gives more opportunity for NanoHealth to strengthen the first screening parameters to reduce false positives, and its associated costs. The Saathis must focus on education and awareness creation to encourage users to seek timely doctor consultations. Factors that determine user's enrollment can be evaluated in prioritizing users before planning for a follow-up visit. This could eventually result in a higher conversion rate of users from screening to enrollment. There is scope for optimizing Saathi performance at various levels of the process from first screening to enrollment to improve the user acquisition rate. Further analysis on the drop out users at various levels can provide guidance.

3.2.2 User retention on plan after enrollment

User retention was assessed by estimating the length of stay of users on NanoHealth Plan after enrollment. We extracted data of users who enrolled on NanoHealth Plan between the period of March 2015 to June 2017. Kaplan Meier survival estimates were used to determine the retention of users on the plan. Figure 7 describes the retention rate of users on NanoHealth Plan.

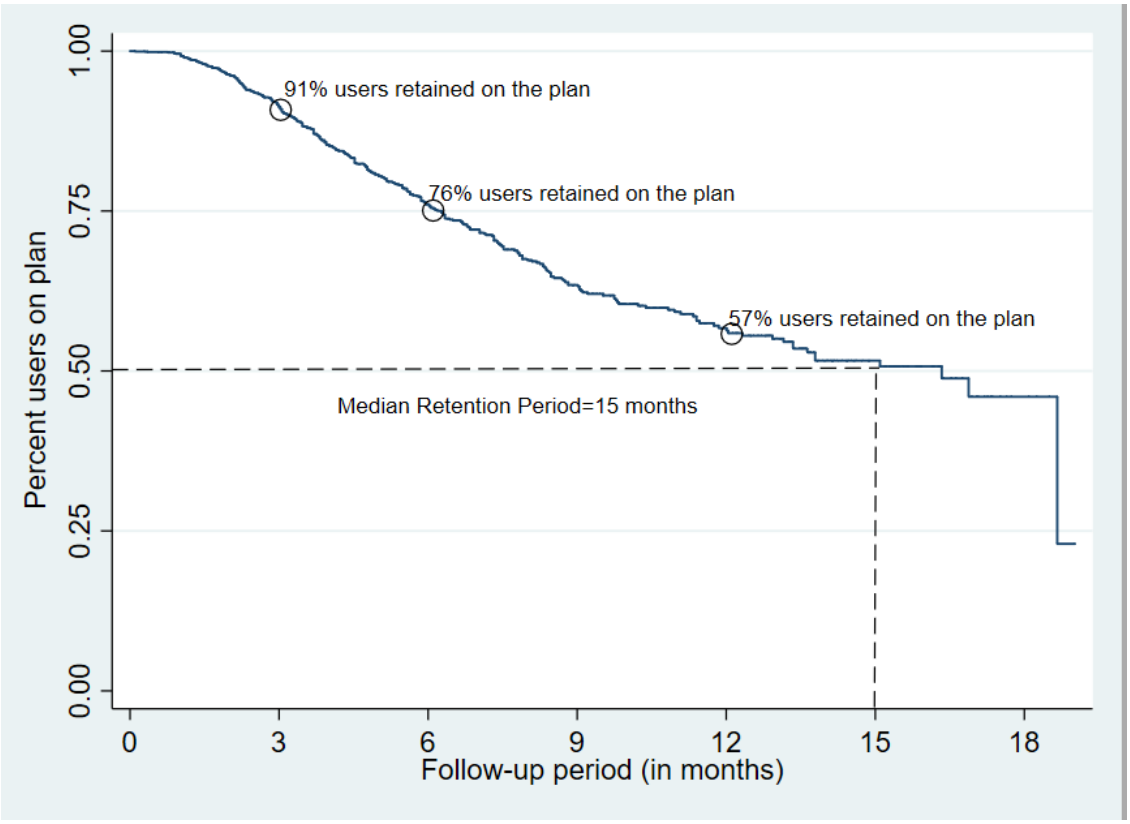

Figure 7: 2-year retention rate of users on NanoHealth Plan

We observed a gradual decrease in the number of enrolled users over time. As seen from Figure 9, more than 90% users continued to stay on the plan at 3 months after their enrollment. This number dropped to 76% at around 6 months and to 57% at around 12 months after enrollment. The drop-off rate declined after that and roughly half of the users continued to stay with the plan at around 15 months after enrollment.

We further conducted sensitivity analysis to understand the reasons of dropping out. Log-rank test was conducted for calculating differences in dropout rates between groups (e.g. gender, previous medical history, etc.). Users who did not have a medical history of hypertension before enrolling into the plan were more likely to retain on the plan as compared to those who did ($p=0.023$). Similarly, users who were not on medication, to control diabetes/hypertension, before enrolment into the plan had a marginally higher retention rate than the users who were on medication ($p=0.045$). No significant difference was found among gender and users with previous medical history of diabetes ($p<0.05$) (data not shown).

This could imply that users who were seeking medical care from providers before enrolling in to NanoHealth plan (e.g., ESI, other public or private practitioners, etc.) either switched back to their previous providers or started to self-manage their disease after using NanoHealth services temporarily.

3.2.3 Saathis' Productivity

User acquisition is directly linked to the productivity of the Saathis on the ground. As per the organizational protocol, every Saathi is assigned to a catchment area covering a population of approximately 5000. Therefore, in order to assess their productivity, we divided their workload into two

components: (i) catchment area target covered, and (ii) number of visits conducted to users' households

From July 2016-June 2017, NanoHealth had, on an average, 30 active Saathis in their team. Overall, more than 20,000 users were reached out to by all Saathis in their catchment area in this period. Figure 8 describes month-wise visits conducted by Saathis who were active in the field for six or more months.

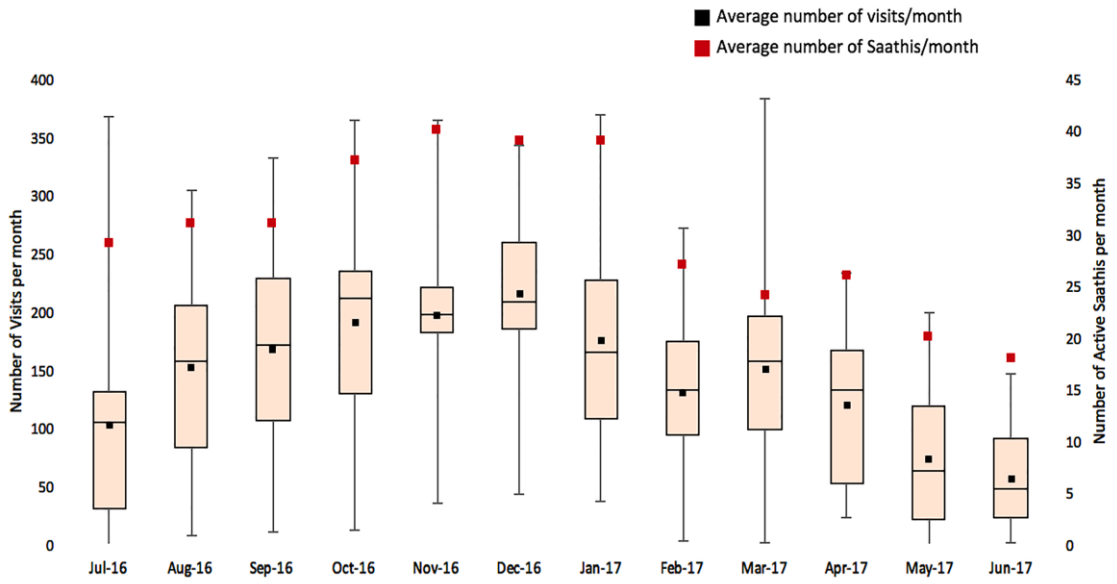

Figure 8: Box plot on number of visits per Saathi per month (July 2016-June 2017)

The average monthly visits by each Saathi was found to be 144 (median=98, IQR=115 to 179). We further subcategorized these visits as first screening, second screening, enrollment visits, and follow-up visits (for enrolled users) to understand the division of time across various tasks. The first screening visits constituted the majority (41%) of total visits conducted, followed by second screening visits (26%) and follow-up visits (23%) (data not shown).

The financial sustainability of the NanoHealth model is directly proportional to the number of enrolled users per Saathi. Hence, we analyzed the number of enrollments per Saathi across a period of one year by each Saathi who has been active in field for six months or more. Figure 9 describes the distribution of number of users enrolled across Saathis over the period of one year.

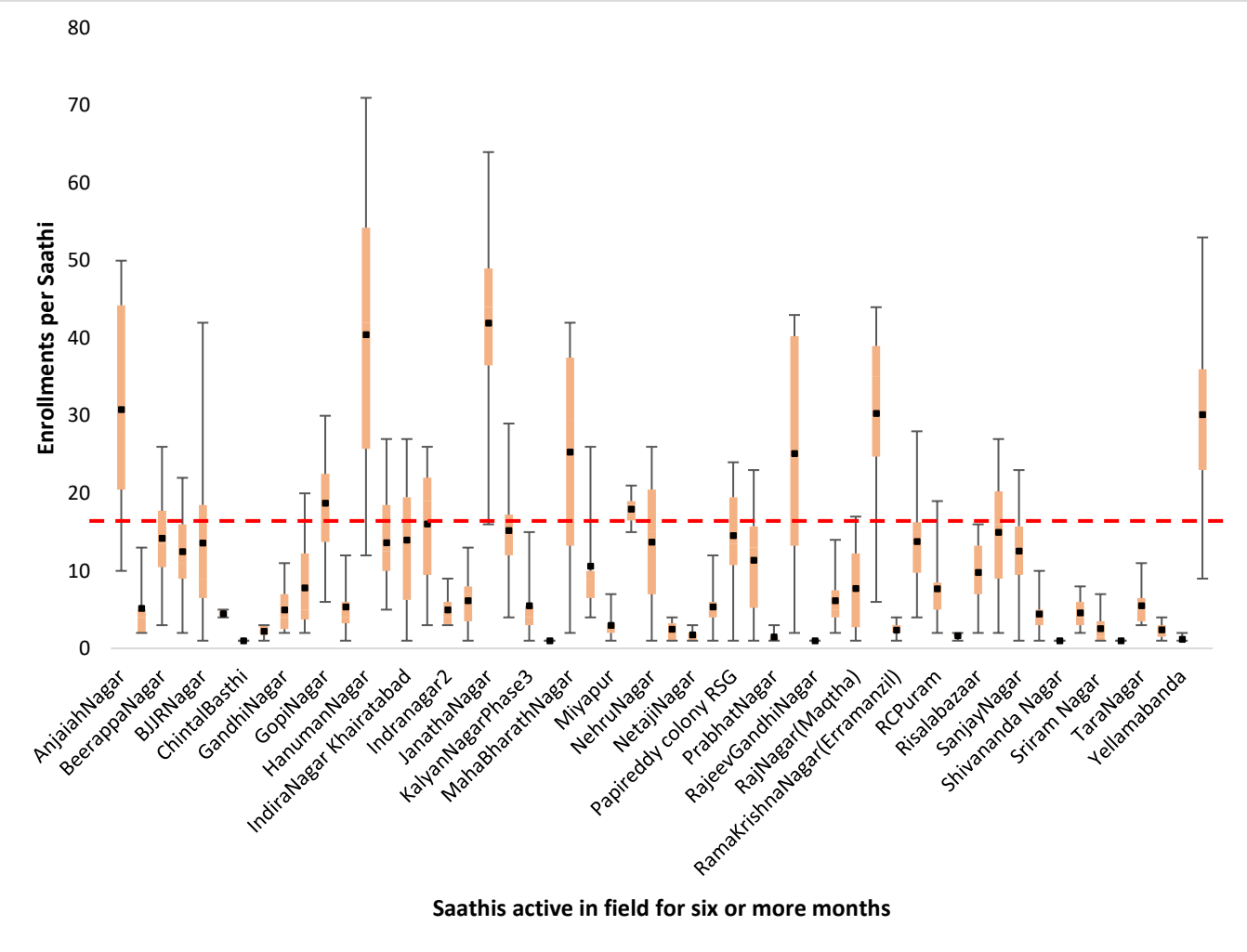

Figure 9: Number of new enrollments per Saathi per month (August 2016-July 2017)

As is evident from Figure 119, that there was a high variation in numbers of enrollments across Saathis. The average enrollments recorded were 11 per month per Saathi. The variation in number of enrolled users across Saathis was dependent on various factors such as reputation of Saathi in the community, location, and duration of service of a Saathi in a particular community. High enrollment rate was found in locations where Saathi's developed a good inter-personal relationship with the community members, had spent an extended time serving the same community, and which had relatively higher socio-economic status of the residents.

3.3 Financial Sustainability

It can be seen from the above findings, that users attainted better health outcomes after enrolling into the plan. However, at the moment, financial sustainability has not been achieved by NanoHealth. Some of the core operational indicators such as user acquisition and user retention directly impact financial sustainability. The current user acquisition at 6.78% with a new user enrolment rate of 11 users per month per Saathi and user retention at 57% after 12 months of enrolment is not financially viable. Therefore, we analyzed the minimum number of conversions from screening to enrolment and minimum retention rate (corresponding to the costs incurred for each) required by NanoHealth to become a financial sustainable model.

Our analysis revealed that the operational costs borne by NanoHealth exceeded the revenue generated by it. NanoHealth offers fixed monthly salary of INR 5000 every month to each Saathi for an average of 120 hours of field activity per month. In addition to this, it also offers a variable pay based on various activities on the field like the number of new users enrolled (INR 30 per user), number of follow-up visits (INR 10 per visit) conducted every month etc. For each step i.e. screening, enrolling and following-up visits of the enrollment process, there is a consumable cost of INR 10 per test.

For this analysis, we included operational costs for each stage (i.e. glucose strips, etc.), Saathi cost (i.e. Time per visit * Saathi wage per hour) and other field cost. The total revenue and the ratio of first screen to second screen was kept constant at current levels (as in August 2016-July 2017) for all calculations.

3.3.1 Conversion ratio (second screen to enrollment) and retention required to be profitable

Based on these assumptions, we developed a user acquisition vs. retention metrics for different conversion ratios and user retentions. In this matrix, the revenue per customer was treated as constant. The matrix describes that for a given conversion ratio, how many months of customer retention are required to break-even or have a positive return. Factors considered for this analysis were (i) revenue per user (ii) number of months for which a user retained on the plan (iii) cost of conducting each visit (screening/follow-up) (iv) number of screening/follow-up visits required to enroll/retain a user on the plan. Figure 10 describes the user retention on plan (in months) required for a given customer acquisition (calculated as conversion ratio from second screen to enrolment) to break-even.

	Customer Retention in Months														
Conversion Ratio (S2-Enrolment)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
10%	-688	-668	-648	-628	-608	-588	-569	-549	-529	-509	-489	-470	-450	-430	-410
14%	-485	-466	-446	-426	-406	-386	-367	-347	-327	-307	-287	-267	-248	-228	-208
18%	-373	-353	-334	-314	-294	-274	-254	-234	-215	-195	-175	-155	-135	-115	-96
22%	-302	-282	-262	-242	-222	-203	-183	-163	-143	-123	-103	-84	-64	-44	-24
26%	-252	-232	-213	-193	-173	-153	-133	-113	-94	-74	-54	-34	-14	5	25
30%	-216	-196	-176	-157	-137	-117	-97	-77	-57	-38	-18	2	22	42	62
34%	-188	-168	-149	-129	-109	-89	-69	-49	-30	-10	10	30	50	69	89
38%	-166	-147	-127	-107	-87	-67	-47	-28	-8	12	32	52	72	91	111
42%	-149	-129	-109	-89	-69	-49	-30	-10	10	30	50	69	89	109	129
46%	-134	-114	-94	-74	-55	-35	-15	5	25	44	64	84	104	124	144
50%	-122	-102	-82	-62	-42	-23	-3	17	37	57	77	96	116	136	156
54%	-111	-91	-72	-52	-32	-12	8	28	47	67	87	107	127	147	166
58%	-102	-82	-62	-43	-23	-3	17	37	56	76	96	116	136	156	175

Figure 10: User acquisition and retention metrics to calculate minimum conversion ratio to break-even

The numbers in red cell denotes a negative return for a given combination of conversion ratio and number of months of customer retention whereas the numbers in green cell denotes is a positive return. We found that a 30% conversion ratio from second screen (people identified at high risk in the first screening, undergo a follow up or second screening) to enrolment can give positive returns in a year's time.

3.3.2 Number of users required per Saathi to be profitable

We also calculated the number of enrolled users per Saathi per month that are required for break-even. A matrix using conversion ratio (second screen to enrolment) vs revenue per visit (calculated as price per month per patient) was created. Different values of minimum number of users required per Saathi per month to break-even were calculated using this matrix. In the matrix conversion ratio and revenue per visit per customer were used as the two levers to calculate the minimum number of users per

Saathi per month required to break-even. Here, the customer retention (in month) was kept as constant. Factors considered for this analysis were (i) Saathi's wage (ii) revenue per customer (iii) average tenure per customer (iv) cost of conducting each visit (screening/follow-up) (v) conversion ratio. Figure 11 describes the number of new enrolments required per month to break even.

	# of new enrollments required per month per Saathi									
	Conversion Ratio (S2 to enrolment)									
Revenue	18%	20%	22%	24%	26%	28%	30%	32%	34%	36%
50			449	229	162	129	110	97	88	82
80	49	42	38	35	33	31	30	29	28	28
100	27	25	24	23	22	21	20	20	19	19
125	18	17	16	16	15	15	14	14	14	14
150	13	13	12	12	12	11	11	11	11	11
175	10	10	10	10	9	9	9	9	9	9
200	9	8	8	8	8	8	8	8	8	8
225	7	7	7	7	7	7	7	7	7	7
250	6	6	6	6	6	6	6	6	6	6
275	6	6	5	5	5	5	5	5	5	5
300	5	5	5	5	5	5	5	5	5	5
325	5	5	4	4	4	4	4	4	4	4
350	4	4	4	4	4	4	4	4	4	4

Figure 11: Conversion ratio and revenue matrix to calculate minimum enrolments required per month to break-even

The numbers in red cell denotes, the minimum number of new enrollments per month per Saathi required to break-even for a given subscription fees and conversion ratio.

We found that with the same assumption of conversion ratio of 30% (from second screen to enrollment) and revenue per customer at Rs.100; each Saathi would require **20 new enrollments every month** to break even. As is evident from Figure 9, though there are some outliers (~7 areas), most of the Saathis have not been able to enroll the target new enrollments of 20 per month.

4. CONCLUSION AND DISCUSSION

The evaluation of the NanoHealth Chronic Disease Management Program has demonstrated a positive health impact in terms of supporting individuals in managing long-term conditions like diabetes and hypertension. Clinical impact demonstrated through the improvement in health of the users enrolled in the NanoHealth program is very encouraging. A significant reduction in blood glucose by 20.1mg/dL, and blood pressure by 9.2/4.5mmHg was observed in members that stayed on the plan between 9-12 months. A visible reduction in the number of NanoHealth users with uncontrolled blood glucose levels and blood pressure levels is also seen.

Operational feasibility is demonstrated through NanoHealth's ability to early identify at-risk users (case finding rate) and continuously manage their health as per the laid-out norms of the organization (220 touches per Saathi per month). However, there is scope for improving operational optimization to improve user conversion rate and user retention rate by optimizing Saathi productivity. The overall productivity of Saathi's can be effectively increased by strategically mapping the outreach area in order to efficiently plan first screening visits. And also, reducing the time spent by Saathis on non-value adding services for example, wrapping-up time can be shortened by training Saathi to bring users back to the focus of the interaction. This would consequently decrease the time spent per user, thereby increasing the number of daily household visits for each Saathi. Risk perception towards the disease of interest was found to be one of the major limitation in retaining the users on the plan. Therefore, educating users about the disease and incentivizing the ones who wish to exit the plan is recommended.

Novel approach of the program and limited understanding of continuous care management programs among users have impacted the conversion and retention of the users on the program, which then, directly impacting the financial sustainability of the model. Moreover, individual motivation to pay for/ invest in programs that yield long-term benefits is low. It is important to identify and partner with stakeholders in the healthcare system that benefit from investing in long term health improvement for potential cost reductions. Healthcare payers- public or private can look at programs such as NanoHealth to improve the fiscal health and sustainability of health products- particularly insurance.

NanoHealth, with an effective and scalable solution for early screening and long-term management of NCDs, should consider partnering with public payers or plugging into integrated health systems where the benefits of early diagnosis and disease management can be internalized through reduced hospitalizations or emergencies. While similar programs have shown significant impact in more developed countries where they have been led to lower hospitalizations and fewer emergency cases, in India this is a nascent space, but an important one.[10-12]Careful evaluation in partnership with government to determine operational scalability in integration with public health infrastructure, measurement of health outcomes, and sustainability would be key to a successful partnership.

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