

## Project factsheet information

<b>Project title</b>	Khushi Baby
<b>Grant recipient</b>	Khushi Baby 107 Avenue Louis Pasteur Boston, MA 02115 +12817258062 <a href="http://www.khushibaby.org">http://www.khushibaby.org</a>
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<b>Partner organizations</b>	Udaipur District Health Society, UNICEF, GAVI, ARM, Mobisoft Infotech, Safran Morpho
<b>Total budget approved</b>	50,000 AUD
<b>Project summary</b>	<p>Khushi Baby (KB) offers a revolutionary patient-centric platform designed to streamline comprehensive data collection, improve decision-making in the field, and aid in resource management.</p> <p>Patients wear their medical history on a Near Field Communication storage chip (\$0.80, culturally-symbolic design, battery-free, waterproof). Health workers can update patient history by tapping the KB necklace to our mobile app. Unlike other existing mHealth platforms, patients can be identified at the point of care, without needing to sync with a central repository of patient data.</p> <p>We have also designed a dashboard that provides health officials with specific, actionable, and timely analytics, such as high-risk expectant mothers who need follow-up or nurses who need more vaccines. Additionally, officials can program automated voice call reminders in the local dialect to ensure families get timely education and reminders through the pregnancy-infancy journey.</p> <p>We expect to see process related impacts, including increases in timely data-driven engagements, completeness of maternal and child health data, and improved antenatal care, hospital birth rates, and immunization coverage.</p> <p>We are currently running our second Randomized Controlled Trial in rural Udaipur, and we hope to use evidence-based data to scale up to the national level in India. Our potential to scale up is promising given our current partnerships with GAVI, UNICEF, and OT-Morpho We are already working with the District Government according to national standards. The government has invested in 10,000s of tablets for frontline nurses, and our challenge is to demonstrate that our platform can robustly meet the needs of the government cadre of frontline health workers.</p>

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## Background and Justification

According to the Ministry of Health and Family Welfare, India sees an estimated 500,000 children die annually of vaccine preventable disease.<sup>[1]</sup> More alarming than this statistic, is the understanding that the statistic itself is unreliable. In the state of Rajasthan, 2.3 Million mothers were left unaccounted for in the state e-health registry between 2011-2016 according to a report from the Comptroller and Auditor General of India.<sup>[2]</sup> Without first knowing which children (and mothers) are being missed, strategies to drive behaviour change for better uptake of essential maternal and child health services would likely be ineffective.

Consider the case of Udaipur, a medium focus district for immunization coverage improvements in southwest Rajasthan.<sup>[3]</sup> Annual Health Survey data (AHS 2012-13, Registrar General of India office) presented full immunization coverage rates of 79.8% in rural areas for those children 12-23 months of age.<sup>[4]</sup> On the contrary, the reputable National Family Household Survey conducted in 2014 found just 37.2% of children in rural areas fully immunized in the same district (NFHS-4).<sup>[5]</sup> For the entire district of Udaipur, Rajasthan's Pregnant Woman and Child Tracking System (PCTS) showed 44.5% as fully immunized in 2013.<sup>[6]</sup> Differences in denominators, sampling strategies, and data quality might have resulted in such a wide range of estimates. Ultimately, the outcome is great uncertainty regarding the extent of the problem at hand at the District level. Deficits in data quality noted at the State and District level must ultimately percolate from the grassroots level - the Villages, where mothers and children are tracked, and where failure to account for mothers and children results in the aforementioned estimates of infant mortality.

## Process

To derive the discrepancies in key health indicators above, one must first understand the process of maternal child health tracking in rural India. Protocols described by the National Health Mission and the Rajasthan Ministry of Health and Family Welfare outline that newlywed couples (i.e. women who may soon enter pregnancy) should be identified by the Accredited Social Health Activist (ASHA) and given a serial number known as the Eligible Couple number. During pregnancy, each mother attends a Maternal and Child Health camp in her village, and she receives a MAMTA card as a personal record for her pregnancy and her child's upcoming infancy. The Auxiliary Nurse Midwife (ANM), who services a Sub-center Catchment area of an average 5000 individuals in plain and 3000 in tough terrain, is expected to see the mother four times during pregnancy and provide antenatal care check-ups (recording any signs of high-risk), maternal vaccines, and iron folic acid tablets and deworming medications. During these visits, the ANM is expected to fill the mother's MAMTA card and her own Reproductive Child Health (RCH) register (a log of all patient data from the camp) with the same data. By month's end, the ANM is expected to calculate the total number of key health indicators that took place at her camps: the number of registrations, vaccinations performed, etc. in central government mandated Forms 6-8 under the National Health Mission (NHM). The ANM also turns in her line-list report from the RCH register showing the individual details of each mother (and child) who attends the camp to the sector level Data Entry Operator (DEO).

The Data Entry Operator enters this line-list report into the Pregnant Woman and Child Tracking System (PCTS), a platform developed by the Government of Rajasthan. After copying values into the web portal for a given patient, the PCTS portal returns an ID for the mother or child known as the PCTS ID. These IDs, along with a due list of the next month's expected patients, is to be presented to the ANM by the DEO or Lady Health Visitor (LHV). The ANM is expected to write the PCTS ID on the Mother or Child's MAMTA card at the next camp check-up. ANMs are salaried government staff, but still are evaluated on the basis of reaching performance targets for various health indicators from registrations to antenatal care check-ups to immunizations given. Primary Health Centers are mandated to have supervisory staff to conduct household spot checks for up to 10% of the beneficiary population to confirm whether mothers and children have indeed received services.

## Gaps

Our observations from three years of field experience in rural Udaipur have shown us gaps in not only in the process of delivery of services but also in the process of data collection (Sherpa 2016).<sup>[7]</sup> These shared

observations have also been documented in a gap analysis of the PCTS system by the Columbia Earth Institute for the district of Dausa, Rajasthan (Songara et al. 2014).<sup>[8]</sup> Generalizability of these gaps is likely to extend throughout India where similar protocols are in place, as per national standards.

At the field level, we have observed ANMs not filling their RCH Registers with all the required 130 columns of the RCH Register spanning from antenatal care to delivery to postnatal care to child registration and child immunization. In some cases, the ANMs do not understand the data to fill. In other cases, ANMs neglect filling the data. Notably, this has particularly been observed in past obstetric history of the mothers during antenatal care. In some cases, ANMs deliberately falsify data. This has in particular been noted for Blood Pressure values, Blood Sugar values, and Urine Test Results, all of which have been seen to be manipulated at the point of care. ANMs have been observed to fill outdated registers with outdated columns or in personal diaries instead of the standard issue RCH Register. ANMs have also been observed to call patients who have migrated to record whether they have availed services from another camp, without physical verification - and then to translate that second-hand data into their reports.

At the field level, we have further observed ANMs not appropriately filling the patient's MAMTA card. In particular, child immunizations are marked as complete with semi-filled dates and also without dates. Mother's ANC details are rarely recorded in full during antenatal care check-ups. The PCTS ID, used to link the mother to child, is rarely written on patients' MAMTA cards. It has been further observed that some ANMs will keep the patients' MAMTA cards with themselves. The ANMs may continue to fill these MAMTA cards as proof of completing care to the patients, irrespective of their actual attendance to a health camp, in order to meet incentivized volume-based health targets. Mothers too, do not always retain their MAMTA cards. Although 92.6% of mothers are estimated to receive MAMTA cards during pregnancy (National Family House Survey, 2014),<sup>[9]</sup> as low as 59.5% of cards are retained by the completion of the child's first year of life (Annual Health Survey 2012-2013).<sup>[10]</sup> In the case that the card is lost, oral history is used to determine the treatment required for the visit and for back-filling data. Mothers, who have been observed to have both poor literacy and health literacy (Nagar 2016),<sup>[11]</sup> may not remember dates accurately enough to convey full information in such scenarios for data to be accurately recorded. The end result is guesswork to provide patient-specific care.

At the primary health center level, the way data is entered into the portal also influences how the ANM collects data at the field. For example, consecutive antenatal care check-ups cannot be entered unless they are 56 days apart. As a result, ANMs have been seen to manipulate the date of the antenatal care visit to meet these input validations on PCTS. On the other hand, the portal also inappropriately excludes data in certain scenarios. For example, mothers may not accurately remember their Last Menstrual Period (LMP Date), which is used to calculate the Expected Date of Delivery (EDD). If the actual Date of Delivery entered exceeds the Expected Date of Delivery, it is rejected and the record cannot be created unless the actual Date of Delivery is adjusted to fall within the listed bounds.

At the primary health center, the ANM is also required to summarize the frequencies collected in her register in Forms 6-8, but does so by hand-tabulating cumulative frequencies. In this step, the ANM may manipulate data so that the cumulative number of patients in the line-list and in the summarized Forms 6-8 match in number. But further differencing analysis on PCTS reveals that line-list data and Forms 6-8 data mismatch on many key health indicators. This difference can be attributed to deliberate mis-entry of health columns, mis-entry of repeated ID columns in Forms 6-8 leading to records being rejected, or from patient migration causing duplicated records. Mis-entry of data may also be attributed to DEOs through human error, and to LHVs/MOs who do not take steps to verify the data accuracy before upload.

Altogether, these procedural gaps contribute to uncertainty both in the higher-level health indicators and local patient-specific records alike. As we see it, the current approach to tracking maternal and child health is overdue for radical change. This change begins with holding the entire system accountable.

## Purpose

The purpose of this initiative is to implement and evaluate of a novel, culturally-tailored, data-vigilant, mHealth platform for rural maternal and child health tracking in India: Khushi Baby. Specifically, this evaluation seeks to

address the knowledge gap in the effectiveness of a systematic multi-stakeholder, multi-component intervention on: improvement in MCH data reliability, MCH data retention, and critically, improvement in data-driven engagements for patient care and delivery of health services to last-mile communities.

Khushi Baby is not the first mHealth intervention concerning health workers to be rigorously evaluated in India (Bokrum et al. 2015), nor the first mHealth intervention to make use of a culturally-relevant wearable for infant health data storage (Marcus et al. 2009, 30-5). Khushi Baby is also not the only solution that digitally replaces the standard RCH. The Government of India, with the technical support of UNICEF India, launched ANM Online (ANMOL) as part of its National Health Strategy. ANMOL, a tablet-based digital solution designed to replace the RCH register, was launched with 10,000+ ANMs in Andhra Pradesh in 2016 without any prior process or impact evaluation. For such system implementations of ANMOL, significant funding has been invested on the part of the Government of India and implementing partners (at least 20,000 tablets have been purchased across multiple states). Despite the agencies involved, the project has been noted to be stalled in the field due to technical and managerial issues. In spite of these delays, funding allocations are still being made in the form of advanced market commitments to tablets for ANMs in the tens of thousands.

ANMOL is just one of many policy commitments made towards improving MCH data tracking in rural India.<sup>[12]</sup> Uttar Pradesh developed an application for ASHAs and ANMs known as mSehat for tracking MCH offline on smartphones. Gujarat and Rajasthan both have built significant State Electronic Health Registries (eMAMTA and PCTS respectively). National standards for Electronic Health Registries for MCH data have also been established in the form of the Maternal and Child Tracking System (MCTS). The broader banner of Digital India has resulted in the registration of over 1 Billion Indian citizens with biometric identification, in part to manage and assess the reach of social welfare schemes throughout India. Indeed, the nexus of health and digitization campaigns in India presents a unique opportunity to re-examine and reimagine the way MCH data is tracked and acted upon.

While Khushi Baby cannot be simply compared head-to-head with ANMOL, nor can it immediately be integrated into existing Government EHR frameworks such as PCTS, this timely evaluation aims to uncover the procedural requirements for a sustainable, impactful last-mile MNCH tracking platform and thereby highlight opportunities for improvement of status quo systems to drive evidence-informed policy change.

Khushi Baby advances a key technological paradigm for MNCH tracking based on principles of decentralization and locally-appropriate design. Other platforms which seek to digitally replace the RCH (in some form) on a mobile device such as ANMOL, Medic Mobile, mSehat, Dimagi's Commcare, claim to be functional offline to cater to rural areas where ANMs serve. However, should a patient migrate from one village to another, as is common for mothers entering the last trimester of pregnancy, then these aforementioned systems require that all health workers have their mobile devices synchronized with a central server at the same time before going to the field for the health camp. Given that ANMs work in rural areas with limited or intermittent connectivity, such a dependence becomes untenable in the field (Bokrum et al. 2015). When mothers migrate to another health worker, their record becomes duplicated. Unique IDs to even look up mother data in the form of large numbers of names with multiple spellings do not always pull-up a match even when the patient record is on the local mobile device. Khushi Baby's approach changes this because the most up-to-date health record remains with the patient, and can be scanned by any ANM to retrieve that patient's history at the point of care, without any dependence on connectivity to a centralized database.

Given the realities of the field, critical skepticism should be applied to any intervention that claims to move the needle on MNCH outcomes without intimately disentangling the intermediate processes required to drive impact. In positing a systematic information, we seek to comprehensively assess the capabilities our system seeks to unlock beyond just our framework for a patient-centric, decentralized record. The KB platform additionally strives to empower ANMs know which children missed their measles vaccines and which mothers are at highest risk of pregnancy complications before visiting her camp; to empower the ANMs to be able to identify the unnamed child in front of her at the VHND camp and know which vaccines to give at the point of care; to give District health officials insight into which ANMs are conducting camps in the first place, which ANMs are low on specific supplies, and which ANMs are under suspicion for collecting data with poor quality; to improve coordination between health workers within the District by informing LHV, BCMOs, and ANMs of high risk patients and

supply-side failures. Last but not least, our platform seeks to educate patients through systematic reminders and educational voice messages in the local dialect so that they may adhere to the schedule of the camps and understand the value of the services being provided.

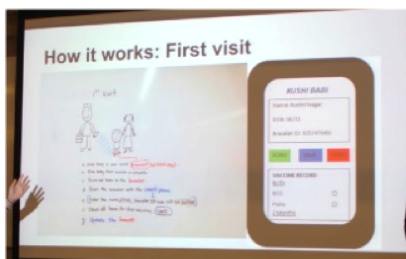
Ultimately, moving the needle for us means rising up to meet all of these challenges, throughout the continuum of pregnancy through infant care, to drive behaviour change for both patients AND health workers who make up the health system in rural India. Our undergirding hypothesis is that better data - actionable and accountable - can bring about better prevention and better care for mothers and children at the last mile.

## Project Narrative



## Project Evolution

Khushi Baby emerged in 2014 from a Yale Center for Engineering Innovation and Design as a class project seeking to tackle the challenges of global vaccine delivery. After identifying opportunity spaces for “appropriate technology” the founding team focused on the opportunity space of data and accountability (or rather the lack thereof) for immunization tracking. Brainstorming and early ideation brought forth the idea of a wearable, digital vaccine record and reminder, to replace ubiquitous and problematic paper-based tracking solutions. User feedback was provided by an NGO, Seva Mandir, working in the Udaipur District of Rajasthan to deliver maternal and child health services, including vaccinations, to beneficiaries in over 100 “last-mile” villages. Paper was identified as a pain point early on, and Seva Mandir agreed to support piloting of a yet-to-be-designed digital tracking system. Subsequent prototyping took place to put together a system that was digitally streamlined, robust enough to function offline, and patient-centric, due to assumed migratory patterns and lack of connectivity. The team’s “AHA moment” came upon realizing that existing Near Field Communication technology could allow frontline nurses to digitally store and retrieve structured immunization card data onto a passive, wearable for the patient, using an Android Application.



**Initial User Interface and Workflow:** The nurse uses an Android tablet to scan the patient's NFC wearable. Using radiofrequency waves, the unpowered NFC chip could be digitally read or updated with a simple tap of the device at the point of care



**First Wearable Prototype:** Off the shelf NFC silicon band (cut and glued to fit the wrist size of a child); note: waterproof and \$2/bracelet

**Figure 1. Initial Prototypes of Khushi Baby's wearable vaccination reminder and mobile application**

MIT's AppInventor was used to build the first demo of the app, which utilized offline data storage, automated logic to suggest due vaccines for the child, NFC read/write functionality, and the ability to send patient records via SMS to a "centralized server." Initially the team thought a wearable for the child (such as existing silicon bracelets for adults), could simply be modified to fit the purpose of the health record. The initial wearable prototype was fashioned accordingly. Team Khushi Baby ended up winning the Yale Thorne Prize for Social Innovation at the end of the semester, receiving \$25,000 in seed funding to fulfil the mission of the class in taking the project from the bench to the field.

After building a proper Android application with professional help, the team visited Seva Mandir to learn firsthand the workflow of frontline nurses running maternal and child health camps. The team also garnered important insights about the form factor of the wearable, ultimately coming to realize that a locally accepted and culturally symbolic form factor of a pendant with black thread for the child could add a critical layer to the proposed innovation. Not only would the proposed wearable be generated from community input, but importantly the wearable, using *kaala dhaaga* or black thread to protect the child from buri nazaar or evil eye, could be used as a social symbol to catalyse awareness and interest in the village-based health camps.



**Figure 2. Child wearing Traditional Amulet with Black Thread (Kaala Dhaaga)**

After returning from Udaipur and growing as both a team and organization, we focused on building a comprehensive system that could involve members across the healthcare value chain: mothers, frontline health workers, traditional birth attendants (local health activists), and administrators alike. What was missing at the time was a dashboard to gather data for required monthly reports and to unlock hidden insights. We realized that we could use the data collected to reach back with the families via automated voice call reminders in the local dialect, with the help of a Twilio API.

Beyond completing the initial phase of tech development, we had an opportunity to have team members spend months, shadowing frontline nurses and beta testing the system. By summer of 2015, we had received research funding and crowdfunding to launch our first randomized controlled trial in 96 villages, serviced by Seva Mandir, to evaluate the efficacy of our system on improving immunization adherence (completion and timeliness of receiving required vaccines) among infants. The trial was supported by a very modest grant from Johns Hopkins Future Health Systems group and in part by the Yale Human Nature Lab. During the process of running this experiment, we worked as a very small team, with a small budget, traversing vast areas under the toughest of conditions. Suffice to say we gained important perspective and insight, and we were fortunate in many regards because our technology (one app version, KB 1.0) was able to hold up for the entirety of the trial (9 months), before ultimately crashing in April of 2016 due to an overload in patient volume, not properly accounted for in the original architecture.

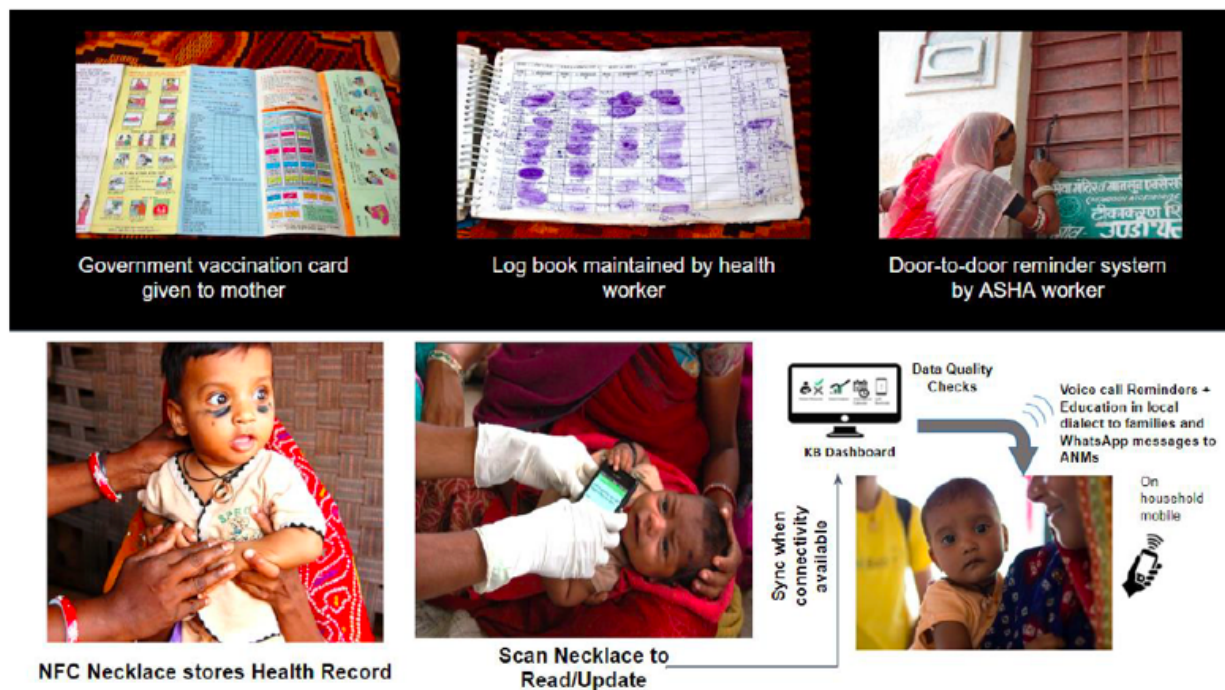


Figure 3. KB System Schematic

Midway through our trial, we were fortunate enough to receive support from UNICEF Innovation, which helped shift our paradigm from simply a research group into an aspiring social enterprise seeking impact through sustainable growth. We too received funding to conduct a larger evaluation, based on the premise that starting our intervention during pregnancy (instead of infancy), could lead to improved maternal and child health behaviour outcomes from 3ie. Our focus shifted onto how we could adapt our system to work within the context of the government's rural health delivery scheme for maternal and child health.



From our early conversations with the Udaipur Chief Medical Health Officer, we quickly realized we needed track well beyond infant immunizations, and cover the data for the entire continuum of care beginning before pregnancy required by the National Health Mission's Reproductive Child Health Register, which is used by over 250,000 Auxiliary Nurse Midwives across the India.

In the summer of 2016, we concluded our first randomized trial, which showed promise of the Pendant form factor in increasing discussion within community. Additionally, the Pendant seemed to be better retained than the paper-version of the health card. Yet we too realized that we had to rethink not only the extent of technology and data captured, but also really consider how different stakeholders would in the long run interface with our platform. From our first trial, we faced difficulties in high nurse turnover, with limited structural support to sustainably continue the project with Seva Mandir. Our camp monitors ultimately turned into the prime end-users for the Khushi Baby app, instead of the intended frontline nurses they were accompanying.

### **Progress under ISIF Asia Technical Scale-up Grant**

The build-up to the partnership between ISIF Asia and Khushi Baby came at a very critical juncture. We were in the midst of rebuilding our entire platform from scratch and gearing up to do our second evaluation with 10 times the number of users across the entire district, this time with the Government (and the world watching; we had in fact just come out having received public support from UNICEF and GAVI). Above that, we too were formalizing our organization, setting up our official HQ, and hiring our first full-time employees at the same time. Again, we were a bit ambitious with our hopes for the evaluation, even for the budget allocation made by 3ie. We were forced to strike up new partnerships in order to subsidize much of the development costs, and were very fortunate to work with multiple partners: OT-Morpho (who committed tablets for our trial through their CSR wing), UNICEF Innovation and ARM (who contributed funding and guidance), Andela (who contributed pro bono development services), and Mobisoft Infotech (who contributed in the form of a software development partnership), beyond ISIF, who provided generous support to carry forward our main phase of software development.

Khushi Baby's objectives with the Information Society and Innovation Fund had been defined as follows:

1. To improve health outcomes in rural Udaipur
2. To improve process outcomes of maternal and child health tracking in rural Udaipur
3. To strengthen our organization's capacity for project management, readiness for scale, and access to investment



Khushi Baby's theory of change is to use Culturally appropriate technology, combined with data vigilance, to ensure awareness of mothers, empowerment of health workers, and activation of health officials to respond to challenges in MNCH at the last mile.

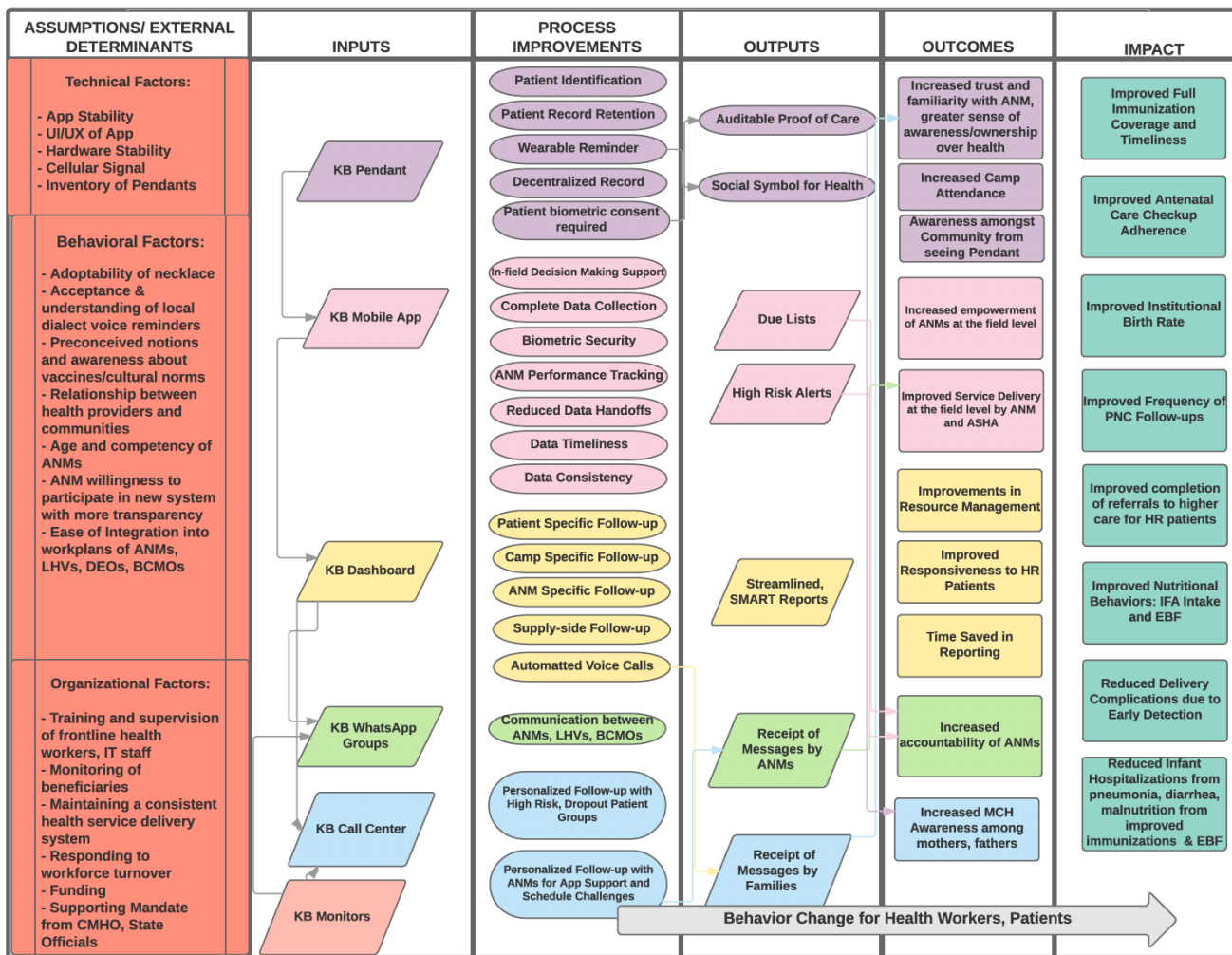


Figure 4. Theory of Change

Since receipt of the ISIF grant, Khushi Baby has designed, built (with the support of Mobisoft Infotech), and deployed its mobile application for maternal and child health tracking amongst 87 frontline health workers (6 months running). The Khushi Baby Dashboard, Actionable Reports (patient lists, high risk patients, supply side failures, attendance reports), and Programmable Voice Call features have been built and deployed. This recent development cycle has involved design of the system on Google PPT, obtaining user feedback through paper-prototyping exercises, extensive hand-holding with frontline health workers, and field-level monitoring of the system deployment.

This recent development cycle was not with its own set of challenges. The first phase of the project involved significant efforts by the KB Team to capture all requirements: both in designing a wireframe for a mobile app with over 50 screens and in translating over 200 data columns into backend tables from the Reproductive Child Health Register into a logical framework for the developers. At the same time, Khushi Baby was working with 1

junior frontend and backend engineer from Andela, along with two summer interns to build the application and backend in parallel. The major technical challenge was in finding a method to store the required data within the cap of 868 bytes for our Near Field Communication Chip. This involved developing a parsing method for compressing and encrypting each field value into the minimum number of bits required. The lack of familiarity (and success) of the development team in build and unit test a model that could implement proper NFC libraries for the required data, in addition to the price point at the time compelled us to strike our partnership with Mobisoft Infotech to employ experienced and professional software developers (between 1.5 and 5 resources per month). Ramping the new tech team required collaboration with the former team over a one month period. A change in the local database framework used on the mobile application along with a steady stream of new feature requirements (such as reworking each button as a custom element that would be user-friendly for the smartphone-naive nurses) delayed the project horizon from an October 2016 completion date until a January 2017 completion date. Over 70 mobile applications were deployed and tested during this critical phase. At the same time, the team on the ground had to maintain proper relations with local stakeholders who were awaiting our multiple delays and false starts after being temporarily satisfied with demos of the KB App and Dashboard. Ultimately multiple ingredients contributed to the journey of our initial phase of development and the challenges therein: our limited managerial experience, our reliance on student and pro bono resources with quick turnover, our limited funds, our shifting feature requirements, limited documentation on NFC-related applications, lack of proper documentation and automated testing in the rush to develop for an already past deadline, and underestimation of the technical complexity required when jumping from KB 1.0 to KB 2.0.

Since launch of our KB App and Dashboard on February 9th, we have deployed only a handful of application builds. These builds have been deployed across three separate tablets, all of utilize hardware and software components of OT-Morpho for biometric authentication: Morpho Tablet BT1, Morpho Tablet BT2, and Data Mini. These tablets were provided free of charge by Morpho as part of a CSR arrangement. However, we soon found out that there were significant hardware issues in the initial batches of Morpho Tablet BT1 received: NFC antenna not working, slow processing, fast battery drainage, screen malfunctions, and software library issues due to an outdated 4.0.2 operating system version. The delay in initial procurement of the tablets led to a delay in testing. The timeline for roll-out meant that we had to deploy hardware initially, knowing that after repeated use, the stability of the tablet could not be assured. Since then, we have phased out over half of the initial Morpho Tablet BT1 devices for the more stable counterparts, but in doing so have had to adjust the software to handle the custom operating system libraries accordingly.

More recently, we have encountered problems on our backend. Subpar documentation from the QA and a lack of an automated testing framework has led to discrepancies in certain fields across various reports. In the past month, the volume of patients reaching the backend has caused us to exceed our memory capacity on multiple fronts: in loading dashboard pages, in downloading reports, and in down-syncing data. We have recently encountered corrupted data being synced by a certain batch of tablets, due to a lack of validations on the front and backend. Such technical issues have required a deeper dive into the overall architecture to ensure system stability with future scale. Approaches including file streaming and background processing, along with optimization of views and reports, has led to real improvements.

Suffice to say there have been moments where the ANMs on the field have lost faith in the application due to the application hanging, sync taking an inappropriate amount of time, and tablet related failures when attempting to scan the necklaces of returning patients. Ensuring system stability continues to be our number one priority, and our approach to project management has certainly matured this past year to deal with the existing issues and challenges to come.

Technical development captures only one aspect of bringing the Khushi Baby project to life. More important is the work conducted at the field level to translate the project into reality. To date 87 ANMs (with over 102 total refresher trainings) and 102 health officials have been trained by a team of 15 KB Monitors and 4 Core Project Staff on the KB App and Dashboard respectively. Initial trainings were conducted in the five administrative block offices for the group of ANMs, including didactic sessions, group trainings, one-on-one trainings, and scenario-based role playing over the course of two days. ANMs were then trained the day before their first camp by

retrospectively registering existing records in the KB App. KB Monitors would then provide supportive supervision and in-field training, visiting each ANM at least once a month. KB monitors were responsible for switching out faulty tablets and hand-holding the ANM in certain aspects such as going with the ANM to the identified network point to sync the data. After covering each ANM with the initial training, those ANMs identified as weak with the application were given extra trainings. KB Monitors would report technical issues in real-time using WhatsApp and disseminate broader findings about ANM performance at weekly meetings held at the HQ in Udaipur.



The team has had to overcome initial resistance from nurses used to filling out RCH registers in a context of limited transparency and accountability. Resistant ANMs have used a variety of tactics to avoid using the app in the field from forgetting to charge the tablet to citing application failures to even convincing mothers in one case that the KB Necklace was bad luck. Other nurses have had challenges in inputting English characters during initial registration and in advancing through the Android application in general. To deal with these circumstances, the KB Monitors and Core Staff have provided motivational interviews, targeted training, and have taken the support of block officials, and local people's representative where required.

Larger systemic challenges do persist. ANMs are still able to invent and manipulate values for key health indicators during antenatal care check-ups. BP, weight, urine tests, blood sugar, and fundal height may be created on the spot without proper measurement. A larger attitudinal change must take place for ANMs to see the value of the data that they were previously just aggregating for no particular agent to act on. This too must come with a shifting in incentives away from meeting health targets, not scaled to the population served, and without an accountability mechanism to check back data fabrication in fulfilment of those targets. We have been able to identify patterns for detecting ANM performance across multiple angles: attendance, time spent per patient, suspicious data trends, completeness of data, duplication of data, and from in-camp observations with our KB Monitoring team. In parallel, we have sought to bring awareness to the ANMs via high risk alert messages in the app itself and high-risk reports communicated over WhatsApp groups in a setting where ANM and health official supervisors can see patients most at risk to take specific actions to follow-up.



A key to understanding our progress has been to engage in a rigorous self-evaluation. With the support of 3ie, we have also been concurrently running an impact evaluation with a randomized controlled trial framework since September of 2016. In doing so we have come to understand our beneficiary and user populations in great detail. 3283 pregnant women from 584 villages were enrolled into the study cohort and surveyed at baseline to assess socioeconomic status, health status, and maternal and child health awareness. 163 Auxiliary Nurse Midwives (ANMs) and 315 Accredited Social Health Activists (ASHAs) were surveyed at baseline to understand attitudes and behaviours towards health delivery at the village level. A separate baseline coverage evaluation survey was conducted with 1243 mothers with children age 12-23 months in 100 villages sampled from the same region to assess health indicators at baseline for the study area. These findings have been summarized in our baseline report.<sup>1</sup>



Altogether, 6000 beneficiaries have been registered into the Khushi Baby platform, 40,000 voice call reminders have been completed, and 60,000+ infant immunizations have been tracked to date. Since partnering with ISIF, Khushi Baby has been recognized as a recipient of the Stars in Global RMNCH grant from Grand Challenges Canada, the Best Mobile App of 2017 from NFC Forum, the E-healthcare award at the national Digital India Summit, CSO Summit Emerging NGO Award 2017, the Global South e-Health Observatory Award from the

<sup>1</sup> [Khushi Baby Baseline Report, 2017](#)

Pierre Fabre Foundation, the national Digital India Trailblazer Award from Honourable Minister RS Prasad and state award from CM Vasundhara Raje, the Aquent Design for Good prize, a featured innovation for the United Nations Day presentation in Delhi, and a featured innovation in the UNICEF 2016 Annual Report.



The currently deployed as a whole offers a distinct set of USPs which elevate the robustness and actionability of the mHealth platform for the ANMs.

After adding stability to the platform, Khushi Baby looks forward to moving into its next phase of action – using data for decision making, and bringing more stakeholders of the health value chain into regular use. The next phase of evaluation will seek to directly compare the data quality of KB vs. existing government tracking systems and report back on user behaviours and satisfaction. We remain optimistic after hearing of reports of increased patient turn-up at camps and instances of mothers proudly owning their Khushi Baby necklace as a health record. We believe this collective effort represents the first steps of a long journey towards accountable maternal and child health care in rural India, and along the way, transparently admitting our shortcomings and insights will be key to advancing our directive forward.

**Table 1. Unique Service Provisions**

- Decentralization of the patient-provider interface; ANMs need not sync before visiting the field in order to retrieve the data of the patient at their camps.
- Data Vigilance with automated data quality scorecard
- Secured Data with AADHAAR grade hardware from Morpho
- Patient Consent and offline biometric authentication at the point of care
- Auditable Proof of Health Interaction
- Symbolic Effect of Khushi Baby Necklace
- Improved engagement from dialect-specific, progress-specific voice calls
- Improved retention of health card
- High risk pregnancy and infancy algorithmic detection
- In-field decision making support for ANMs
- Actionable report formats for all health stakeholders: supply-side failures, attendance reports, high risk reports
- Actionable communication channels for all health stakeholders using WhatsApp
- Focus on end-to-end process from design to development to deployment to M&E
- Strong Public-Private-Partnerships with domain leaders in software, hardware, biometrics, mobile messaging, health policy, and local governance
- Built as compatible with requirements of National Health Mission RCH Register
- Expandable health passport into future domains, including referrals to high risk facility
- Integration between KB Backend and AADHAAR Payments Bridge for tuning of incentives to meet health indicators and data quality targets
- Evidence-informed with 2 Randomized Controlled Trials

## Indicators

Indicators	Baseline	Progress assessment	Course of action
<b>System Functionality</b>			
Crash-Free Users		From the period of May - August 71.4% of users were crash-free with 97.9% of sessions as crash free. The same deployed build remained in the field since April 11 across all users.	Root cause analysis revealed issues in the NFC scanning process. Validations were placed to resolve known issues on the front end. Some crashes due to hardware specific defects were addressed by replacing the affected hardware.
Proportion of crash-free hardware		87 ANMs are using KB tablets in the field. Of 168 total tablets received, 81 tablets were replaced (52% crash free)	We identified early on stability issues coming from MorphoBT1 tablets and initiated a plan to secure replacements from our partner OT-Morpho. MorphoBT2 tablets were procured, although they were not available in sufficient stock. As a result, we also worked with Morpho's partner, Data Mini, to acquire tabs with Morpho compatible components. Cross-platform deployment was never the initial intent, but proving the system on the reasonably priced Data Mini will later be important when advocating for scale-up of the platform. Our KB Monitors identify defective tablets within 48 hours of a reported issue and collect the tablets for analysis and replacement from HQ.
Proportion of Defective KB Pendants		TBD	In the case a Pendant of a returning patient does not display the patient information upon being scanned, the KB App allows the ANM to select "tag not functional", search the local database for the same patient by name, and initialize a fresh Pendant with the current check-up details. On the backend, a counter is employed to determine the number of replacements required. Initially the logic in the counter overlooked a use case in which the ANM could rescan the same Pendant as a replacement (which would in effect make the Pendant a false positive). This issue has been resolved recently to ensure proper categorization moving forward. Of note, just because a Pendant appears to not be properly scanned and is then subsequently replaced, does not mean that the Pendant indeed was defective. More likely is the chance of a hardware related issue in the NFC library. KB Monitors help corroborate the number of true replacements by conducting camp-level observations.
Median time to sync data	< 2 days with KB 1.0	< 1 day with KB 2.0	Time to sync data is a function of multiple factors: distance from camp to network point, training of the ANM, responsiveness of the KB Monitors, and stability of the sync protocol under increasing patient load. Each ANM up-syncs data for her camps and down-syncs data for all camps for all sub-centers in the Primary Health Center under which the ANM operates. On average 100 mothers and children down-synced per week, usually over a 2G or 3G connection. Recently, increases in patient volume have increased down-sync time at the field level to over 30 minutes in some cases. Optimization on the backend and on the local database insertion has been implemented to reduce this lag by a factor of 5-10 times.
<b>Patient Record Retention</b>	As per RCT 1, 98% of mothers retained their child's KB Pendant through the receipt of the first three vaccines. While over 90% of mothers receive a government-issued MAMTA card, our baseline survey results show just half of these mothers retaining the health card by the time their child has just finished infancy.	TBD - Midline Survey (started July 2017)	We do have an automated process to count KB Pendant replacements due to the specific reason of tags being lost. As in the case of KB Pendant defects, this counter has recently been revised to account for a missed use case in which false positives could be counted. Automated collection of lost tag frequency will be corroborated by in-field visits by KB Monitors in our Midline Household Survey.  In our cluster RCT, we will compare the proportion of records retained in control vs. treatment arms and use a logistic regression model to determine the increase in likelihood of record retention due to the adjusted effect of the KB Pendant being provided.



Indicators	Baseline	Progress assessment	Course of action
<b>Data Quality</b>			
Data Consistency: proportion of patient records with corresponding record in the backend, and backend records with corresponding identifiers on the patient health record copy	2.3 Million mothers were missing in the PCTS backend from 2011-16 after audit by the CGA India. To our knowledge, no such data exists at baseline regarding the match rate of records from field to backend, which in theory should be 1:1	TBD - Midline Survey (started July 2017).	In our cluster RCT, we will measure the proportion of records matching from field to backend, and from backend to field for both mother and child patient groups in both control and treatment study arms. We will use a logistic regression model to determine the adjusted effect of the Khushi Baby system on data consistency outcomes.
Data Completeness: proportion of required fields filled for both mother and children cards at the time of registration	Our field observations have shown that ANMs incompletely fill values on the patient health record and skip certain fields altogether. In turn, a patient who brings her card to a different provider can only present an incomplete medical history to inform clinical decision-making.	TBD - Midline Survey (started July 2017)	In our cluster RCT, we will measure the proportion of required fields completed on the patient record, by patient group, in control and treatment study arms. We will use a logistic regression model to determine the adjusted effect of the Khushi Baby system on data completeness outcomes of the patient record.
Data Validity: proportion of records accurately filled as per the actual health interaction	Our field observations have shown us ANMs fabricating and manipulating data at the point of care and during month-end reporting.	TBD - Camp-Level Observation Survey (started June 2017, analysis underway) Analysis on KB mother data has revealed suspicious trends in measured variability for BP, Urine Test, Fetal Heart Rate, Fundal Height, and Weight during antenatal care check-ups.	Data validity in treatment vs. control arms will be assessed through multiple processes. Qualitative mapping will be conducted after speaking with ANMs, ASHAs, LHVs, DEOs, and Medical Officers to understand issues in the data collection process. Analysis on data collected on the KB backend will also be conducted to investigate long-range patterns in parameter distributions. Ongoing Camp-level observation surveys will be conducted to see ANM behaviour change in the field over time. Information, Education, and Communication will need to be provided to ANMs to drive long-term behaviour change. Specific protocols have been added such as geotagged attendance and biometric authentication of the patient, in addition with feedback on WhatsApp channels and block meetings where supervisors are present to encourage proper data entry.
<b>Data-driven Engagements</b>			
Automated Voice Calls Completed	Despite over 80% of mothers having access to mobile phones, and despite mobile number being collected during registration, less than 2% receiving any kind of message from the government concerning their antenatal care, delivery, or infant care at baseline.	40,000+ to date 14 Voice Call Messages were recorded in Mewari and programmatically sent to specific patient groups for the purpose of reminding beneficiaries to come to their specific camp and to inform them about best practices during pregnancy and infancy.	Specific Voice Call Messages have been modified to account for more specific patient groups. Duplicate phone calls have been controlled for. The updated camp schedule has been uploaded to the backend to ensure that reminder messages do not cause beneficiaries to attend camps that are no longer active for that particular day of the month. Automated one-way calls have been supplemented by targeted, personalized two-way calls to mothers' due for delivery, high risk mothers, and dropout mothers.
Personalized Voice Calls Completed	At baseline the majority of mothers do not receive personalized voice calls regarding reminders or education. In some cases, the ASHA worker may call mothers to come to the camp on the camp day. In some cases, ANMs may call mothers who have migrated away from their catchment area to obtain records of health status for monthly reporting.	500+ to date Personalized voice calls are conducted by a KB Core Staff member. Details on patient outcomes are collected. The patient is asked about presence of specific danger signs. The patient is given a chance to ask questions. General advice on best practices are conveyed to the mother or father who receives the phone call.	Of 376 mothers called for due for delivery, 14 cases of infant death or stillbirth had been identified via the KB Call Center's personalized voice calls. Moving forward we intend to complete case investigations of these deaths by organizing meetings with the concerned mothers, ANMs, and from assessing the antenatal care history of the mother in the KB Backend.
Targeted messages to ANMs for supply side gaps and high-risk patients	ANMs are given feedback in monthly block-level meetings according to their hand-prepared reports from previous months in the more proactive blocks at baseline. Previously, health administrators received records from camps at least a month after they occurred, preventing them from taking immediate, informed action to prevent stock-outs of vaccines, medications, and necessary health equipment. Community health workers didn't have the tools to be proactive about ensuring that high risk patients attend camp.	Under the KB system, as soon as the data is synced, health administrators have organized camp data right at their fingertips through the dashboard--allowing them to keep track of everything from stock-outs, to ANM attendance & performance, to camp attendance & trends, to high risk reports. KB's use of duellists reminds health workers which patients should visit the next camp, so that they can focus on ensuring those patients attend	We've noticed that data actionability on the KB Dashboard has not come directly as health officials may not be accustomed to using such web apps regularly. In order to drive such change, we are using a far more common form modality of disseminating important actionable insights on WhatsApp groups, with the hope of driving curiosity towards usage of the KB Dashboard.

Indicators	Baseline	Progress assessment	Course of action
<b>Health Workers Trained</b>		87 ANMs trained 129 Refresher trainings for ANMs in the past 3 Months 102 Health Workers given at least one training	Continued in-field supervision for ANMs still facing difficulty will be required. Health stakeholders will need to be given 2-3 more trainings each, with specific directives on integrating the KB Dashboard into their regular work plan.
<b>Active Health Workers using KB System</b>		87 ANMs active	Continued in-field support and improved app stability will be required to maintain ANM usage
<b>Health Behaviour Change Outcomes</b>			
Completion of four antenatal care visits	16.2% at Baseline	TBD – End-line Survey	In our cluster RCT, we will measure the proportion of children completing immunization by the end of the first year within our treatment arm, to determine the adjusted effects of number and type of phone call received, and whether the KB Pendant was lost on immunization adherence.
Institutional Delivery	>80% at Baseline		
Completion of full immunization by 12 months	<25% at Baseline		

## Project implementation

Project activities	Input	Outputs	Timeline	Status
Mobile application development and testing	Mobisoft Engineers (1-2.5 resources per month)	The KB 2.0 application	Aug 1 - Feb 17 (Development and Testing) Phased manner rollout began on 9th Feb 2017 and completed on 13th April 2017 across the five administrative blocks. Feb 17 - Ongoing (post launch iteration and Development)	Completed  On-going
Dashboard development and testing	Mobisoft Engineers hired (1-2 resources per month)	The KB 2.0 Dashboard	Nov 1- Feb 17 (Development and Testing) March 17 - Ongoing (post launch Development)	Completed  On-going
Research Activities: Enrolment of Study Cohort Baseline Coverage Evaluation Survey ANM and ASHA Baseline Surveys	30+ surveyors, 5 field supervisors; 2 months 30+ surveyors, 5 field supervisors; 2 months 15 KB monitors, 2 months	3283 Mothers enrolled in research cohort 1243 Mothers assessed for baseline health 163 ANMs and 315 ASHAs assessed for attitudes and practices	Sept – Oct 17  Nov- Dec 17  Feb- April 17	Completed  Completed  Completed
Stakeholder Engagement at: Local level  State level  National level	10 meetings with District Collector, District Chief Health Medical Officer; Reproductive Child Health Officer;  Demo Principal Health Secretary, Joint Secretary, Department of Information Technology. Partner agency Morpho in talk with other states  Ministry of Information Technology Demo, has shown interest to replicate the model in Bihar state.	Preliminary approval and feedback on application; received  Need to connect with more contacts at provincial and national level.  Proposal submitted	Nov - present  April - present  April - present	On-going  On-going  On-going
Roll-out of KB System	5 Training Sessions at each Block Office Camp level Observations and Supportive Supervision by 15 KB Monitors KB Call Center for Remote Tech Support	KB system rolled out in 2 blocks in Feb, another 2-block added in March, and 1 in April; BCMOs and LHVs given trainings on the dashboard; hosted KB summit in May 87 ANMs and 102 Health officials trained	Feb - April'17	Completed

## Communication and dissemination

Communication has been targeted towards stakeholders and decision-makers at the district, state, and national level. Additionally, dissemination of reports and participation in workshops have been targeted audience of international funding agencies. Of note, receipt of national and international awards and interviews with major news media (Zee News, Times Network) has also affected the Khushi Baby communication plan to communicate a message around unique service provision of the system for proposed country-wide scale up. Funding for communication and dissemination has been provided in part through ongoing grants, except for the case of social media and crowdfunding campaigns, which have been self-supported.

**Table 2 Recent Communication and dissemination development**

### December 2016

- The three-week business development workshop in Singapore run by APNIC; introduced to start-up community and mentors in the South-East Asia region. Discussed sustainability models with reinsurance companies and connected with the AVPN DealShare network for future funding opportunities in collaboration with CSR
- Participation in month end District Health Society meeting with CMHO and former-DC; gave progress report. DC wanted us to focus on e-health card for urban Udaipur, but later agreed to allow us to continue with our current efforts, similar interest was received by Municipal Commissioner of Udaipur.
- Town Hall meeting at Safran Morpho HQ and meeting with MD, Mr. Sanjeev Shriya. Safran agreed to commit new tablets to our efforts (and replace faulty tablets). Townhall discussion lead by Ruchit and Shahnawaz in front of 150+ employees covered the context for collaboration.

### January 2017

- GAVI and UNICEF Innovation announced partnership to support Khushi Baby at invite only breakfast prior to World Economic Forum 2017
- Launch of Khushi Baby Program officially during the month end District Health Society meeting on January 24, 2017, on the eve of national republic day. DC and CMHO were chief guests. RCHO, DPM and block heads also attended.

### February

- Yale Spark Conference for Social Entrepreneurship - Ruchit was a panellist
- Jodhpur Start-up Fest: Shahnawaz participated as speaker in Impact Talk
- CMHO and Block Managers were met several times during the month
- Udaipur District Health Society (DHS) Month-end Meeting was attended

### March

- NFC Forum Innovation Award: Best Mobile App in 2017; award received in Las Vegas
- Digital India Summit: Tech for Good E-Healthcare Award, presented by Minister of Transportation; met Shri RS Prasad, Minister of IT in passing and got connected with his additional Private Secretary. Follow-up has since been slow
- 2-week engagement with Business Development Consultant Team from MIT Sloan School of Management; explored additional use cases of the platform by visiting urban/rural schools, ration shops, and health centers
- Focus was on roll-out of the KB system in Jhadol, Gogunda, and Salumbar
- CMHO and Block Managers were met several times during the month
- DHS Month-end Meeting was attended

### April

- Field Visit by STARTUP Brics COO
- Phone call with JNJ Public Health Team
- Field visit by HCL Foundation
- CMHO and Block Managers were met several times during the month
- DHS Month-end Meeting was attended

### May

- KB Summit: see notes below
- Jaipur Visit to MoIT; met with Additional Joint Secretary and Integrated Child Development Scheme (ICDS) team. They have requested dossier to propose to the Technical Director
- SPO Conference on Innovation in CSR attended by Md Shahnawaz, who was a featured panellist; KB was also awarded the Emerging NGO Award 2017
- Times of India (Times Now) interview released
- Focus was on roll-out of the KB system in Jhado, Gogunda, Salumbar, Lasadia, Sarada

- CMHO and Block Managers were met several times during the month
- BCMO's were given specific dashboard training. LHVs were given training on the application
- DHS Month-end Meeting was attended

June - July 2017

- Meeting with Principal Health Secretary, highest health official in the State of Rajasthan to demo the KB System
- Initiated engagement with Ministry of Electronics and IT for replication project in 5 blocks of the Patna District of Bihar
- Participated in 3ie midline synthesis workshop in Delhi, where we interacted with 14 other global innovations to improve infant immunization undergoing impact evaluation
- Participated in Global South eHealth Observatory Summer University and Awards, hosted by the Pierre Fabre Foundation; KB Demo was livestreamed across 15 universities around the world
- Participated as a mentor (2016 Pacesetter) in GAVI INFUSE 2017 Summit in Barcelona for identifying innovations in the immunization space for scale-up.

KB Summit Takeaways

Attendees: Li (Gavi), Dey and Manish (Morpho), Subhadra and Rohit (BCG), Dr. Sanjeev Tak (CMHO Udaipur), Henriette Ahrens (UNICEF India), Bhupendra Tripathi (BMGF), Radhika Menon (3ie)

- Li, Dey, Manish, Subhadra, Rohit have joined us on our Visit to the Namchot MCHN Day camp in Salambar
- the CMHO of Udaipur. Dr. Sanjeev Tak, has joined us in the field, providing valuable suggestions for the platform and management, and being our strongest advocate
- a productive meeting at the UNICEF India office with Ms. Ahrens the Deputy Representative of Programmes for India for giving us a chance to demo our platform
- With Dr. Tripathi, Anaita, Radhika, Li, Dey, we have shared our progress and demo our platform at the BMGF (Bill and Melinda Gates Foundation) office

## Project Management and Sustainability

Khushi Baby's approach to project management is unique for a social enterprise and research-guided non-profit. Beginning in 2014 as a class-project for students interested in public health, the group of founding students transitioned their project into a Non-Profit structure after winning initial seed money. Coping in the following year was coupled with fortunate cold-emailing that led to the discovery of the current COO. 2015 saw the organization focus on research, conducting its first Randomized Controlled Trial. All members were unpaid and working remotely and part-time, balancing their academic obligations. Interns came during summer vacation periods to advance research work. Otherwise, research efforts of the small 8 people surveyor team were managed remotely. Part-time development of the software and hardware was also done on a contract or pro-bono basis. In 2016, concurrent with support from UNICEF Innovation, the organization made a major shift in its operational paradigm to function beyond a research group as a sustainable social enterprise. In 2016, the first full-time employed core staff (on-site) was hired and since then the project has grown both in full-time employees and volunteers to address the various required areas and competencies covered by the project: public health, software development, biostatistics, anthropology, field research, operational management, design, fundraising, and social media. Most team members were found via being friends one to three degrees away from the founding group.

The project is managed by Ruchit Nagar (CEO), who is also a first-year MD Candidate at Harvard Medical School (in Boston) and Mohammed Shahnawaz (COO), who is full-time on the ground in Udaipur, the site of operation. The Khushi Baby team currently consists of 4 full-time program management staff (salaried, on-site); 2 full-time project assistant staff, 3 summer interns (on-site); 15 field monitoring staff (contractors); 2 full-time contracted developers (remote); 7 part-time, remote volunteers focusing on data, fundraising, technical program management, and design (remote). The team is spread across 7 cities and 4 time zones. Team members possess qualities of deep skill and in other cases, the ability to wear multiple hats.



Project Management tools such as Google Suite, Slack, Google Hangouts, and WhatsApp are used to keep the globally distributed team aligned and on-task. Daily stand-up calls with tech, research, and leadership are used to maintain pace of work against deadlines. Weekly stand-up calls on Hangouts are held on Sundays as an all-hands for the team to understand cross-divisional progress and discuss challenges or opportunities. The internationally distributed team has advantages of being able to participate in a global range of summits, conferences, and other opportunities to establish networks, donors, or partners.

Khushi Baby's current approach to sustainability has been borne on the back of partners and grant funding. As mentioned before, partners have committed significant funding, pro-bono hardware, pro-bono services, introductions to key health officials, frameworks for rigorous evidence generation, software development support, and most importantly the ability to actually test and deploy our system with real nurses taking care of real patients. In so doing, these partners have elevated the capacities of our young, inexperienced team (average age < 25). In turn, we have found our niche as a boundary-spanner, drawing connections between the right partners in different domains to present a full-spectrum solution that can robust enough for deployment at the last mile.

To further unwrap these connections, Khushi Baby is partnered or works closely with UNICEF Innovation, GAVI, Bill and Melinda Gates Foundation, Safran Morpho, Mobisoft Infotech, 3ie, Boston Consulting Group, and the Udaipur District Health Society. Khushi Baby also collaborates with academic centers at Yale, Georgetown Medical School, and Harvard Medical School. Khushi Baby also leverages business partnerships with Go2Tags and Twilio. Khushi Baby has been funded by ISIF Asia, 3ie, Yale, UNICEF Innovation, ARM, and has pending grants with GAVI and Grand Canada Challenges.

UNICEF Innovation has helped connect KB with UNICEF India, the chief consultant of ANMOL, the existing nationally backed platform for maternal and child health tracking. Boston Consulting Group has helped link Khushi Baby with the Principal Health Secretary (highest health official at the State) and is jointly working with KB to devise new modules for the platform to cover requirements for future scale-up and integration into the State budget line items.

Khushi Baby's procurement of tablets is met through a partnership with OT-Morpho (90 Tablets, provided free-of-cost as part of a CSR initiatives). Khushi Baby is also working with OT-Morpho to approach their already established Government Customers in multiple States of India as they look to fulfil advance market commitments

for tablets for 10,000s of ANMs. Khushi Baby and Safran have jointly advocated for a future-ready tablet with necessary NFC and biometric features (compatible with Khushi Baby software) to be considered for bulk order. Khushi Baby's procurement of necklaces is met through by purchasing stock from Go2Tags in China. That too could shift to India-based manufacturing, as supported by the OT-Morpho subsidiary, Smart Chip Ltd. Software development is lead in-house in collaboration with a team at Mobisoft Infotech, in Pune, and the software platform leverages partnerships with Twilio.org to deploy voice call reminders at scale. Moving forward, Khushi Baby looks to add telecos and pharmas concerned with tracking their vaccinations to the last mile to the cadre of public private partners required to scale the system country-wide in India and elsewhere.

Ultimately, the path to long term sustainability will be achieved by expansion, first in Rajasthan, when we reach integration with government platforms such as PCTS. Should the Central Ministry of Health find inspiration from our model, their National Health Mission seal of approval can enable our standardized platform to empower over 250,000 front line health workers who see over 25.6 million newborns every year. Demonstrating our unique service provisions and especially our robustness in the field with the introductions provided by UNICEF and GAVI can allow us to leapfrog incremental growth from district to district and reach real scale in an already catalytic Digital India ecosystem.

As outsiders, inroads to the central government have been few and far between. We have been fortunate to meet the Union Minister of IT and Electronics, Honourable RS Prasad as the Recipient of the Digital India Trailblazers Award (November 2016) and the recipient of the Digital India Summit for E-healthcare (Feb 2017). As of last week, we were able to follow-up on a connection made with his private secretary which has landed us a prospective project in Patna, Bihar, the home district of the Union Minister (about 2-3x the scale of our current operations) with full mandate and even promise of government-backed funding. We will need to continue to make inroads by engaging stakeholders, but more importantly by continually refining our locally optimized solution, and by extracting the unique value we hope to provide in terms of data-driven engagements and streamlined, decentralized health follow-up.

## Project Outcomes and Impact

Impacts for the Khushi Baby 2.0 deployment are centered on generating process efficiencies and improving program efficacy of maternal and child health tracking and follow-up. Measurements of impacts on infant and maternal health will be by proxy through completion of maternal and child health service delivery and uptake. To isolate the impacts of the Khushi Baby system, a randomized controlled trial framework has been employed for a cohort of 3283 pregnant women in rural Udaipur. While final results for both quantitative indicators and qualitative findings are still pending, intermediate outcomes and opportunity spaces as feedback from the field are described below.

**Table 3. Intermediate Outcomes**

- 6000+ registrations across 300+ rural villages
- 25000+ calls completed to beneficiaries
- 40,000+ infant immunizations tracked
- 87 Frontline health workers (ANMs) trained on Application
- 102 Health officials including Medical Officers, Supervisors, and Data Entry Operators given at least one training on the Application and KB Dashboard

15 KB Monitors have presented important feedback after spending 6 months in the field supporting the deployment of the system.

1. ANMs have received equipment as a result of our supply side failure report, as highlighted in block meetings.
2. ANM absenteeism has decreased, even in times of the monsoon; nurses have expressed to KB Monitors do not wish to be called out in block meetings for missing camps.

3. Phone calls are having a tangible impact. In one camp in our catchment area, Chaali, 10+ new mothers are coming to camp per month to be registered. It has been observed at the campsite that mothers discuss what kinds of voice messages they are receiving (because the messages are specific to their particular progress). ANMs are advising mothers to bring their own phone numbers, not their husbands', if possible. ASHAs are able to load balance their work and focus on reaching the mothers who are harder to reach and further away, now that more mothers are coming independently with the remainder of the KB Call. One mother was planning on leaving for another state the next day, but changed her plan after receiving a KB reminder message.
4. The Pendant is a desired object within the community, and mothers are in fact identifying with the pendant as their health card. One mother attended the Sayara PHC and presented her necklace as the health card. At the PHC there was no tablet with a KB App available, so the health worker instructed the mother to send someone to retrieve her MAMTA card. In the future, we intend to equip both PHCs and CHCs with the KB App; in the interim, however, it is important to ensure training of the medical officers and LHVs (who supervise ANMs) on using the Dashboard when such patients come in.
5. ANMs who previously did not know the vaccination schedule are now able to follow the 'Vaccines Due for Today' page and follow the directions for each patient.
6. ANMs are making use of the 'Scan Mother Tag' feature, which reduces their time of data entry when registering the child and links the child to the mother record in our backend, so we can trace the continuum of care.

Moving forward, we look to capitalize on increasing the following areas of data-driven engagements:

- Supply Side Failure Reports
- ANM Attendance Reports
- Improved Due List interface to track mother and infancy through sub-categories of pregnancy and infancy
- Automated High-Risk Ranking algorithm for mother and child for high risk reports
- Improved communication via WhatsApp
- Infant Death Case Investigation

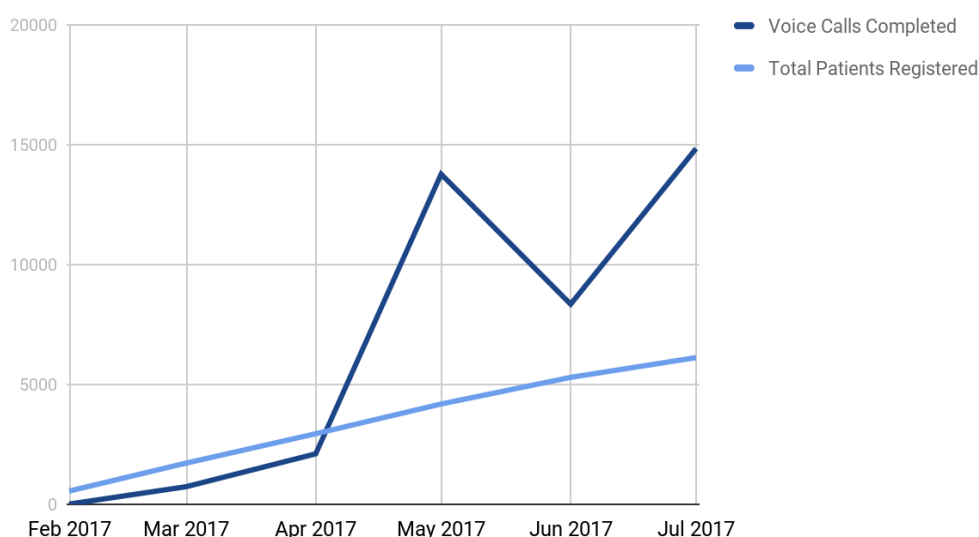
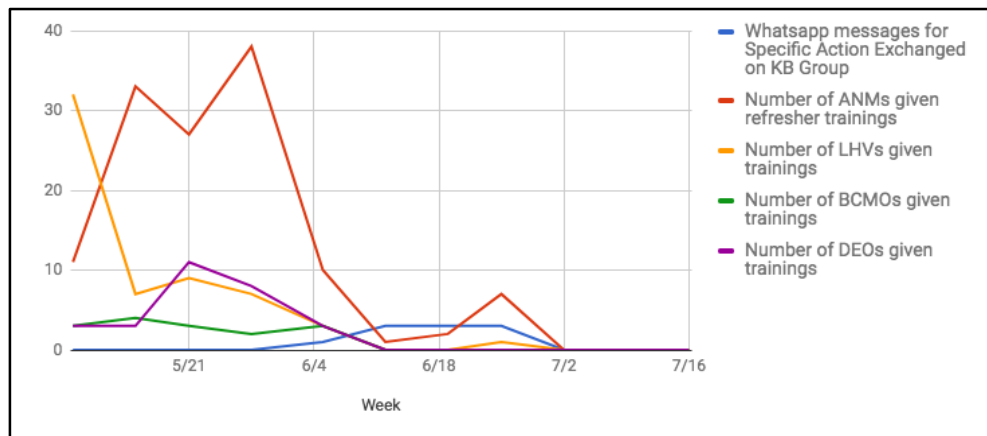
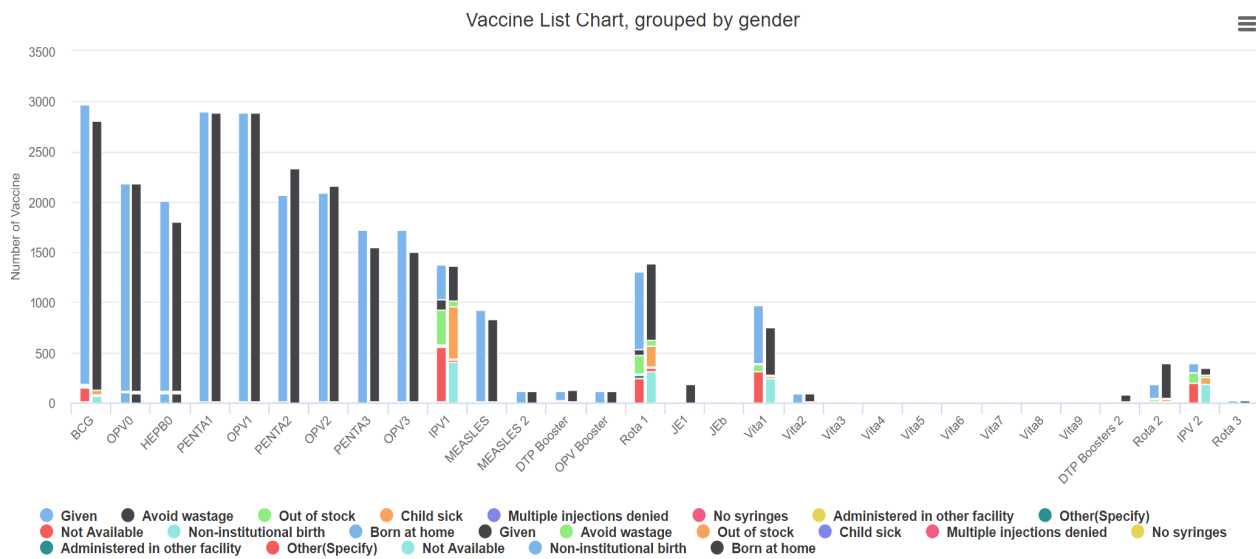


Figure 5. Patients Registered and Reached over KB Roll-out

To date, 5000+ (mothers and children) have been registered in the KB platform and have been given pendants. A total of 25,000 educational voice calls and health camp reminder calls have been received by families during pregnancy/infancy. These calls are placed in the local dialect.



**Figure 6. Health Worker Training and Communications during Rollout:** Over 150 health workers and health officials have been trained to use the KB Dashboard and App.



**Figure 7. Vaccines Administered and Denial Reasons:** Over 60,000 vaccinations have been tracked with the Khushi Baby System to date. Reasons for vaccination denial at the point of care, including supply-side failure or demand-side failure, are also parseable.



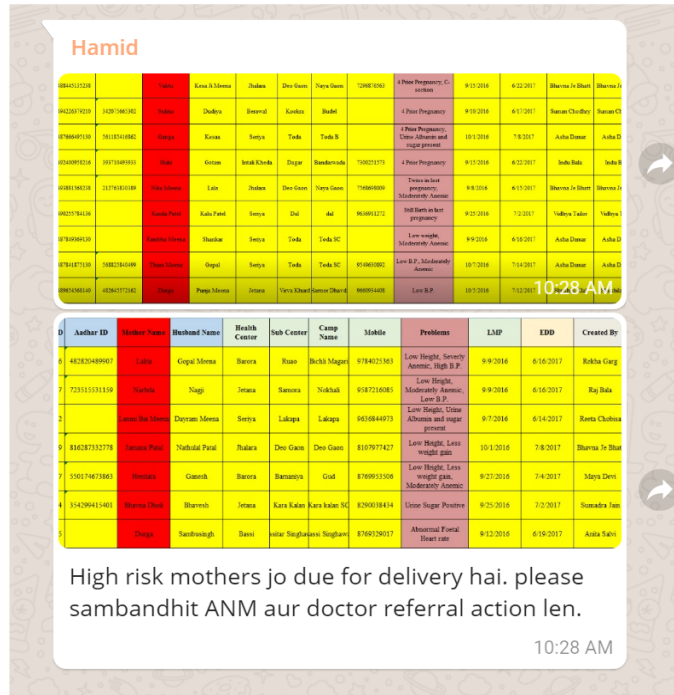


Figure 8. High Risk Reports and WhatsApp Communication Pictured are the top 10 highest risk mothers as identified by algorithms, after accounting for data quality patterns. This list of mothers is communicated to a group of ANMs via a geographically ordered WhatsApp group. Phone numbers of the mother/family are provided when available, along with reasons for their high-risk categorization so that ANM, LHV, BCMO can take specific follow-up and encourage the mother to receive transportation to the District Hospital for further work-up. Automated algorithms are under development, such that weekly reports can be disseminated to the 5 geographical blocks where ANMs using the KB system are working. The effect of this system on behaviour change of nurses and health officials, in response to the data, is still being evaluated.

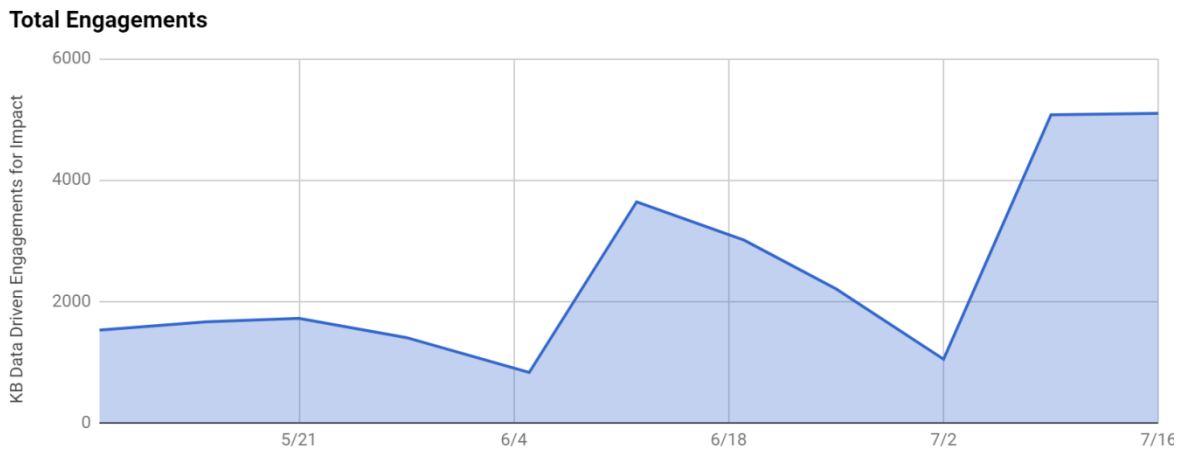


Figure 9. Total Count of Patient Engagements. Engagements include: due for delivery calls, supervisory sessions held at low performing camps, focus groups held with poor performing ANMs, calls placed for high risk mothers, stock outs, equipment issues and the like.

Weekly calls are placed to mothers who are expected to deliver in the next few weeks. The purpose of this call is to follow-up with their care and ensure that they have a plan in place for institutional delivery. Unfortunately, these calls also reveal details about delivery outcomes that may have already passed, such as premature deliveries or stillbirths, producing vignettes that warrant further investigation using the data collected on the KB platform:

*Case: Infant Death #3: "One Mother (Pt ID: 1493273974283) attended 3 Antenatal Care Check-ups and denied receiving any automated voice call messages from the KB system. The mother showed signs of extremely low Hb (unclear if this was an entry error) and excessive weight gain in the final check-up. Despite her severe anemia, she did not receive IFA tablets three consecutive times due to the IFA tablets being out of stock. The mother's female child was born at home on approximately May 2 and died 15 days later. According to the recorded EDD from the LMP date, the baby would have been 5 weeks pre-term. Of note, the mother had had a past stillbirth which would have increased her risk of pregnancy and delivery related complications."*

## Expected Impact

Using our multifaceted KB system, we expect to make large-scale impacts on data collection, quality, and tracking. We hope to see increases in data-driven engagements month-to-month, as monitored through our action log by the district health officials, increases in completeness of maternal and child health data sets (to cover over 50% of all required fields), increases in retention of medical records by patients (aiming for 95% retention rate of the Khushi Baby necklace as opposed to 60-80% observed with the paper card), and increases in data acquisition timeliness (we are seeing data return in 2-3 days compared to 30+ days without our system). Ultimately, we hope to improve antenatal care coverage (4 visits during pregnancy), hospital birth rate, and full immunization coverage rate (via our improved decision making in the field and engagement via voice calls + the cultural campaign effect of the Khushi Baby necklace itself).

The Khushi Baby outcomes are twofold: to improve health outcomes and process outcomes. Khushi Baby seeks to trigger behavioral changes among both, mothers and healthcare providers to improve health outcomes. Through the social engagement of the KB necklace and voice call reminders, we aim to improve adherence to antenatal and postnatal care, increase hospital deliveries, and increment the number of fully vaccinated children through measles (opv 1-3, penta 1-3, measles). Among health workers, we aim to improve clinical decision-making skills to help workers follow-up with high risk expectant mothers and nurses who need more supplies.

In terms of process outcomes, we're improving record retention and streamlining our data collection into the state e-health registry. We expect to see process related impacts, including increases in timely data-driven engagements to act on vaccine & medication stock-outs and equipment failures, completeness of maternal and child health data, and improved antenatal care, hospital birth rates, and immunization coverage. In our ongoing midline survey, we're measuring the retention of the medical record under KB vs. government systems, comparing the level of completeness of both records, and assessing the Khushi Baby necklaces' and MAMTA card' accordance with their respective backend databases.

## Overall Assessment

The Khushi Baby team has conducted extensive field work in Udaipur to design, deploy, monitor and evaluate this technological platform. In doing so, the team has come to understand the demographic profile of the mothers, ANMs, ASHAs, and other health workers. The team has also come to learn and understand the journey of stakeholder engagement - it took over a year to convince the CMHO to write a letter and become an advocate for our platform, and still there are small factions of ANMs in certain regions who remain resistant to taking up the platform.

The team has come to appreciate the challenges and responsibilities borne by the ANMs. The combination of workload, poor facilities and supplies, the government mandate to fill paper records at the end of each month, the lack of accountability mechanisms, the lack of demonstrated value of data collection, and the need to meet health targets results in the ultimate deterioration of ANM data quality and thereby care provision.

The team also sees opportunity in the prospect of engaging ANMs (who affirmed the need for a system that didn't require them to carry a hefty register for multiple kilometers, and one that would save their time for monthly

reports) and mothers alike (many of whom have access to a cell phone but who have not yet been engaged on this medium for either ANC, PNC or immunizations). Although mothers claim to be informed by ASHAs generally, these interactions do not translate into specific, actionable knowledge of maternal and child health on the part of the mother. This too suggests an opportunity for targeted and automated dialect specific voice call messaging.

Behavior change on the part of the health management (the intended KB Dashboard users) will require a phase-wise approach of enticing officials with snippets of data in a digestible format, beginning with WhatsApp. The goal of these messages is to display the data in such a way that the health officer can pick up the phone and delegate direct action. But this behavior change must be led initially by the KB team demonstrating how the data can be used to take action.

The ANM and the Health Official alike should not see the application as extra work. Although current government mandates for reporting and paper proofs do maintain a burden at the end of the month, the current application's 'Search Patient' feature allows for more rapid, unfalsified record entry and quick retrieval of patients from the tablet's database. Still some nurses, especially those in an older age range, struggle with using the tablet. Others do not pick up the application until the Monitor arrives on the campsite. Currently, some ANMs view the tablet as additional work because they are used to keeping the data in a handwritten diary, which they then use to fill in the Reproductive and Child Health (RCH) register. Using the 'Search Patient' tool and scrolling through the data is seen as more difficult than using their diary. However, the aim is that eventually, the need for record-keeping in the ANM's personal diary will be eliminated altogether.

After launching our platform in 5 different districts & over 300 villages in Udaipur since February and after shifting our focus from implementation to data for action, we have overcome delays and hurdles with stakeholder engagement to bring together multiple different components despite unpredictable funding windows: recruitment, inventory for necklaces, inventory for tablets, application development, testing and feedback, baseline surveys, stakeholder engagement, and marketing and promotion. Much of this progress can be attributed to the many extra hours put in by the full-time field team. Every challenge is improving our platform and ultimately bringing us closer to better patient and process outcomes. As we've seen this past few months, our success can be attributed to many factors: our active, deeply involved field supervision, our refresher trainings for ANMs, our incorporations of ANM requests (like the 'Search Patient' feature), and our consistent follow-ups and communication with ANMs, patients, monitors, and health officers. We've actively engaged with LHVs and BCMOs through our trainings and mobile messaging to help them learn our dashboard and take direct action for high risk mothers and address supply side shortages. The monitors' interactions with the ANMs have been insightful because they have been able to ask ANMs questions, report issues, and provide updates on works in progress.

There are additional improvements in ANM performance through the use of the KB system. For example, field monitors report that ANM absenteeism has decreased, even during the current monsoon season, because ANMs are held accountable for missed camps by KB monitors at regularly held block meetings. Also, those ANMs who are actively using the KB application are more closely following the vaccination schedule through the app's 'Vaccinations Due for Today' page and following the directions for each patient. Similarly, they are making use of the 'Scan Mother Tag' feature, which reduces their time of data entry when registering the child. These positive signs indicate the potential that the KB system has to facilitate the ANM when fully utilized.

Through our block-wide meetings with health workers and officials, we have discovered that the invaluable resource of the supply side failure report on the dashboard has allowed many ANMs to receive new, functional health equipment, as well as prescription restocks. The impact of our call system through the dashboard cannot be underestimated either; for example, in the village of Chaali, unprecedented numbers of new mothers are attending camps to be registered. Mothers are often overheard at camps discussing and comparing their ANC checkup progress that is reflected in their personalized phone calls.

Khushi Baby looks forward to moving into its next phase of action - using data for decision making, and bringing more stakeholders of the health value chain into regular use. The next phase of evaluation will seek to directly compare the data quality of KB vs. PCTS and report back on user behaviors and satisfaction.

## Recommendations and Use of Findings

Our goal is to scale up the KB platform throughout India to a cadre of 250,000+ ANMs and 20,000+ district health officials, all working under the same banner of the National Health Mission, to provide essential services to over 25 Million mothers and newborns annually.

To those outsiders or insiders looking to build a robust system for tracking maternal and child health for a state or country in the development sector we would recommend the following takeaways

- The full time salaried team must have in-house skillsets in the following areas: Public Health Management, Public Health Field Research, Android App Development, Backend Development, Stakeholder Engagement expertise, UI/UX and Human Centered Design, Graphical Design, Financial Management, Grant Writing and Technical Report Writing, Statistical Analysis, and HR
- Assured funding must be in place to account for upfront costs of platform development, iteration, local travel and stakeholder engagement before the signing of the MoU.
- Extensive field work and stakeholder engagement must be initiated from the onset of the project. Community-generated pain points must be uncovered from in-person observation over an extended period of time. Designers must bring a partly-built solution upon which end users can also contribute feedback. Stakeholder-derived standards for data collection must be gathered during the requirements definition phase with flexibility to account for requirements which are moving targets
- An MoU must be signed with the governing body who agrees to initiate the pilot or scale-up. This MoU should clearly define that alternative data capturing systems will not be put into place concurrently. The system still must be flexible enough to account for the fact that beneficiaries may also visit non-intervention zones and must accommodate retrospective data already collected by previous systems.
- Remote and in-person accountability mechanisms must be developed to see through the intervention is properly being implemented by the end user. Users will need to be categorized by skill level and given appropriate supportive supervision
- System design should not require that frontline health workers to have synced their tablets prior to conducting a health camp. Connectivity at the field level or even at the ANM-level should not be taken as something within any agent's control.
- Extensive testing must be conducted on all fronts: hardware, software (front end and backend)

To those policymakers considering scaling pilot projects for tracking maternal and child health we would recommend considering the following

- Policymakers should be vigilant of new innovations, including those in the non-profit sector, which are at the forefront of the development. They should take the initiative to visit the field and understand the strengths and weaknesses of multiple platforms before going directly for scale.
- Policymakers are especially responsible for creating an ecosystem in which entrepreneurs should not be burdened by certain legal and financial approvals. That may cause distractions from the innovation itself, which requires constant iteration and improvement.
- Policymakers should consider the evidence base for solutions that are being proposed for scale in the innovation sector. There is a large gap between those conducting research on which interventions work, and those translating interventions into sustainable policies that create real impacts on the ground
- Policymakers should give due consideration to those organizations working on an end-to-end solution, including considerations for training, deployment, and M&E when weighing between the various mobile and digital platforms in the landscape
- Policymakers should give due consideration to those organizations in public-private partnerships with demonstrated track records of deploying technology at scale and conducting due research technology before deployment

To those funders who are looking to support early mid, and later stage social enterprises looking to build a maternal and child health tracking platform which will last, we suggest the following:

- Providing sufficient upfront funds and disbursing funds within a two-week period of the expected date of disbursement
- Visiting the team to see the innovation in the field
- Encouraging alternative forms of communication of final reports such as explanatory videos
- Reducing the technical and financial reporting requirements and restrictions to allow change makers on the ground to dedicate due time to getting the innovation off the ground and running
- Considering multi-year support so the team can work with assured financial stability
- Provision of untied contingency fund with the implementing organization independent of deliverable bound tranche payment system.

## Bibliography

**Tips:** Include complete bibliographic references to all sources (printed, on-line, quotes, etc) used to prepare the different sections of this report. The APA style guide offers examples about how to reference a variety of sources. <http://www.apastyle.org/learn/quick-guide-on-references.aspx> (as accessed on 3/7/2013).

[1] Mission Indradhanush <<http://www.missionindradhanush.in/about.html>>

[2] Goswami R. [2.3 million pregnant women in Rajasthan 'missing' between 2011 and 2016](#). Hindustan Times. May 1, 2017.

[3] Medium focus district label was provided under the [Mission Indradhanush campaign Phase II](#), a national campaign to improve child immunization coverage.

[4] [Annual Health Survey 2012-13](#)

[5] [National Family Household Survey 2014](#)

[6] [PCTS](#)

[7] Sherpa, D. A Study on Developing an mHealth Solution as an Alternate Recording and Reporting System for Auxiliary Nurse Midwives in Udaipur District of Rajasthan. Thesis. 2016.

[8] Columbia Earth Institute. [Pregnancy Child Tracking and Health Services Management System \(PCTS\) Gap Analysis Rajasthan](#). 2015.

[9] [National Family Household Survey 2014](#)

[10] [Annual Health Survey 2012-13](#)

[11] Nagar R. Tying Community Engagement with Appropriate Technology at the Last Mile: A Cluster Randomized Trial to Determine the Effectiveness of a Novel, Digital Pendant and Voice Reminder Platform on Increasing Infant Immunization Adherence among Mothers in Rural Udaipur, India. Thesis. 2016.

[12] Ministry of Health and Family Welfare, Government of India. [Healthcare for All - Three Years of Transforming India](#). 2017.

Bhasin, V., 2007. Medical anthropology: a review. *Ethno-medicine*, 1(1), pp.1-20.

Borkum, E., Sivasankaran, A., Sridharan, S., Rotz, D., Sethi, S., Manoranjini, M., Ramakrishnan, L. and Rangarajan, A., 2015. *Evaluation of the Information and Communication Technology (ICT) Continuum of Care Services (CCS) Intervention in Bihar* (No. 2e2826deedb94ee18890653d81cb601a). Mathematica Policy Research.

Columbia Earth Institute. [Pregnancy Child Tracking and Health Services Management System \(PCTS\) Gap Analysis Rajasthan](#). 2015.

Marcus, A., Davidzon, G., Law, D., Verma, N., Fletcher, R., Khan, A. and Sarmenta, L., 2009, February. Using NFC-enabled mobile phones for public health in developing countries. In *Near Field Communication, 2009. NFC'09. First International Workshop on* (pp. 30-35). IEEE.

Ministry of Health and Family Welfare, Government of India. Healthcare

[Three Years of Transforming India](#). 2017.

Mission Indradhanush. <http://www.missionindradhanush.in/about.html>

Goswami R. [2.3 million pregnant women in Rajasthan 'missing' between 2011 and 2016](#). Hindustan Times. May 1, 2017.

Gibson DG, Ochieng B, Kagucia EW, Were J, Hayford K, Moulton LH, Levine OS, Odhiambo F, O'Brien KL, Feikin DR. Mobile phone-delivered reminders and incentives to improve childhood immunisation coverage and timeliness in Kenya (M-SIMU): a cluster randomised controlled trial. *The Lancet Global Health*. 2017 Apr 30;5(4):e428-38.

Government of India MOHA. Annual Health Survey 2012-13 Fact Sheet Rajasthan. 2013.

Jain, S. and Agrawal, S., 2005. Perception of illness and health care among Bhils: a study of Udaipur district in Southern Rajasthan. *Stud. Tribes Tribals*, 3(1), pp.15-19.

Nagar R. *Tying Community Engagement with Appropriate Technology at the Last Mile: A Cluster Randomized Trial to Determine the Effectiveness of a Novel, Digital Pendant and Voice Reminder Platform on Increasing Infant Immunization Adherence among Mothers in Rural Udaipur, India* (Doctoral dissertation, Yale University).

(NFHS-4) NFHS. District Fact Sheet Udaipur, Rajasthan. Government of India Ministry of Health and Family Welfare; 2015-2016.

Rahman, A., Malik, A., Sikander, S., Roberts, C. and Creed, F., 2008. Cognitive behaviour therapy-based intervention by community health workers for mothers with depression and their infants in rural Pakistan: a cluster-randomised controlled trial. *The Lancet*, 372(9642), pp.902-909.

Sherpa, D. A Study on Developing an mHealth Solution as an Alternate Recording and Reporting System for Auxiliary Nurse Midwives in Udaipur District of Rajasthan. Thesis. 2016.

Swider, S.M., 2002. Outcome effectiveness of community health workers: an integrative literature review. *Public Health Nursing*, 19(1), pp.11-20.

Venkat, P.G., 2016. *Intermediate Assessment of the Khushi Baby cRCT* (Doctoral dissertation, Yale University).

World Health Organization. Immunization coverage cluster survey: Reference manual. World Health Organization; 2005.