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SAVEMOM: THE SMART WEARABLE SOLUTION FOR MATERNAL HEALTH CARE

In January 2020, Senthilkumar Murugesan and Dhinesh Pandian were reviewing the last five years of their company, JioVio Healthcare. Senthilkumar was chief executive officer of JioVio Healthcare and Pandian was co-founder. Over the previous five years, they had built and implemented into their company a new cloud-based maternal health care solution called Savemom. The software, which was an Internet of Things application, was designed for early detection of preventable complications that occurred during pregnancy to ensure a safe birth, especially in rural India. Complications tended to arise due to expectant mothers missing regular antenatal doctor check-ups, poor nutrition, and inadequate medication, even though these services were provided free of cost by the Government of India. Although government officials appointed health care workers to visit and counsel expectant mothers on proper preparedness for the birth, the death rate of mothers and children was still high.

As a social entrepreneur, Senthilkumar had collaborated with various stakeholders in the central and southern parts of India on several iterations of his ideas. One result of his dedication and hard work was Savemom's Allowear device, a smart wearable product for rural mothers-to-be. The Allowear device was intended to improve India's maternal mortality ratio (MMR)[1] in line with the government's strategy to make every pregnancy a joyful experience. Several aspects of the Savemom technology had gone through regular changes, based on process outcomes and feedback. One such change was building the AlloTricorder health measurement device for health care workers. Senthilkumar and his team had painstakingly worked on making this tool useful for doctors at health care centres.

However, many doctors were unhappy with Savemom's teleconsulting platform, which was called Allogate. Some doctors complained that the platform, which sent doctors all health information from the pregnant women, had increased their workload by almost ten times! Senthilkumar felt that both the problem and solution to this latest issue lay with the users. The Allogate technology provided only a bridge from the patients to the doctors. However, Savemom had to find a way to assure doctors that their concerns would be effectively addressed.

[1] The maternity mortality ratio measured the rate of deaths of women occurring during or after pregnancy, including post-abortion and post-delivery periods, per 100,000 live births.

THE BEGINNING: A PERSONAL STORY AND THE FIRST PROTOTYPE

In 2015, Senthilkumar was pleased to hear that his sister Manimala was expecting her first child. However, he was less pleased to find out that she kept missing her monthly antenatal check-ups, which provided regular medical care during a pregnancy. Manimala and her husband were living in Vilangudi, a small town about 10 kilometres from Madurai, in the southern Indian state of Tamil Nadu. Senthilkumar was shocked to hear that his sister would avoid attending the critical and mandatory doctor visits. He asked why she would make this choice and Manimala explained that since she did not drive, her husband would have to accompany her to the nearby primary health centre for each visit and wait approximately three to four hours to see a doctor, despite having booked the appointment in advance. The consultation with the doctor lasted only a few minutes, and her husband would then drive them back home. Each brief visit would force her husband to miss work for the entire day. The process was extremely tiring and inconvenient for both Manimala and her husband. So, every month, on the day she was scheduled for a consultation, Manimala would decide whether or not to attend based on how she felt. "We would skip the check-ups, especially when I felt okay and there were no indications otherwise," she explained.

Senthilkumar was aghast to hear about his sister's reasoning, which was endangering both her and her baby's health. He began reading about the importance of regular check-ups for expectant mothers and the incidence of high-risk pregnancies. The government provided eight free antenatal check-ups to each woman expecting a child. But the idea was obviously not working. If Manimala was missing some of her monthly visits, other expectant mothers were likely missing even more. Eager to learn more about the issue, Senthilkumar spoke to Manimala's doctor about the process for the monthly visits. Upon arrival at the primary health centre, the patient was registered and given a token number. During the wait, a nurse checked the patient's vital functions (e.g., weight, blood pressure, temperature, heart rate) based on instructions from the doctor. Senthilkumar quickly sensed an opportunity for using technology to improve the process. The doctors he consulted confirmed that they would accept a digital version of the patient's vital functions data if it was prepared in the same format that the nurses used.

Senthilkumar, who was a twenty-six-year-old engineer, decided to experiment with a technology solution for his sister's problem. He bought a blood pressure monitor, a thermometer, a weight scale, and a pulse oximeter. All devices displayed their readings on a screen. To avoid alarming Manimala in case of abnormal vital parameters, Senthilkumar replaced the display from each device with a Bluetooth chip. He then built a basic prototype in the form of a watch (see Exhibit 1).[2] Senthilkumar asked his sister to wear the device like a watch and click a button on the device when she was due for her monthly check-up. The device would connect via Bluetooth to a special server and record the necessary health measurements (e.g., blood pressure, temperature saturation). He then informed the doctors that they would receive a text message with a link to his sister's medical information. Clicking the link would open a web page in a browser showing his sister's vital measurements, much like those provided by the nurses. If everything was normal, the doctor could tap the "Good" button. In case of any abnormalities in the measurements, the doctor could ask the patient to come to the health centre for a consultation.

When a consultation was required, an application (app) that was part of the overall program could register and book an appointment for the patient with the health centre, issuing a token number linked to the hospital system. The app could also send a text message to the patient's husband regarding the need for an appointment. In response, the husband could confirm that he would be taking his wife to the doctor or ask the app to book a ride with Ola, one of India's ride-hailing services. Using a public interface, the app

[2] Senthil Kumar, "Med4dev_Challenge#4_Teamlotronic," July 24, 2016, YouTube video, 2:47, https://www.youtube.com/watch?v=yNe4rvQki6M.

provided his sister's home as the pickup location and the primary health centre as the destination, where his sister could have a consultation with her doctor.

Manimala's pregnancy experience was smooth and uneventful. Senthilkumar's app provided her with the comfort of knowing that she was being monitored by her doctor and that her husband was fully notified about her situation. The doctor was pleased with the service the technology provided. It also reduced the number of calls from patients and relatives, who were worried but did not have exact vital measurements available. A key benefit of the app was the automatic uploading of data directly from the device, avoiding human error.

Senthilkumar soon realized the commercial potential of his technology when family and friends started asking for a copy of the app for their own use. After some research, he discovered the high prevalence of the problem across India that his app could address. However, before launching the app as a commercial service, he decided to research relevant statistics on maternal mortality and the country's health infrastructure.

TACKLING THE SCOURGE OF MATERNAL MORTALITY

In 2015, the United Nations adopted a set of Sustainable Development Goals (SDGs) as a "universal call to action to end poverty, protect the planet and ensure that by 2030, all people enjoy peace and prosperity."[3] In total, seventeen SDGs spanned different sustainability areas but were integrated, with any one action on one front affecting all others. Category 3 of the SDGs related to good health and well-being, which considered widening economic inequalities and challenges such as non-communicable diseases. SDG 3.1 set a goal of reducing the global MMR to less than seventy per 100,000 live births by the year 2030. Many women died during, or immediately after, childbirth due to a variety of complications. Most of these issues were preventable or treatable if addressed on time.

Over 90 per cent of maternal deaths occurred in low-income and lower-middle income countries. India accounted for approximately one-fifth of global maternal deaths. In 2000, India adopted the United Nations Millennium Development Goals (a precursor to the SDGs), committing to reduce maternal deaths.[4] Over the previous two decades, India had made considerable progress in reducing the country's MMR from an estimated 254 per 100,000 live births in the two-year period of 2004 to 2006, to about 122 in 2015 to 2017, and further down to 113 in 2016 to 2018.[5] However, India was a vast and diverse country and the MMR number varied across regions, income levels, and other demographics.

India's federal government and various state governments had introduced measures to reduce MMR under the National Health Mission.[6] By strengthening health systems for maternal health, the governments were providing services such as monthly antenatal check-ups, birth delivery by trained personnel, promotion of institutional birth delivery, and access to emergency obstetric services. In addition, many states had implemented cash transfers to expectant mothers of up to ₹18,000[7] to improve maternal health.[8] These

[3] "The SDGs in Action" United Nations Development Programme, accessed January 6, 2022, https://www.undp.org/sustainable-development-goals.
[4] "Goal 3: Good Health and Well-Being," United Nations Development Programme, accessed January 6, 2022, https://www.undp.org/sustainable-development-goals#good-health; "The SDGS in Action," United Nations Development Programme, accessed January 6, 2022, https://www.undp.org/sustainable-development-goals.
[5] Dr Poonam Khetrapal Singh, "India has achieved groundbreaking success in reducing maternal mortality," World Health Organization (WHO), June 10, 2018, https://www.who.int/southeastasia/news/detail/10-06-2018-india-has-achieved-groundbreaking-success-in-reducing-maternal-mortality.
[6] "Maternal Mortality Rate," Government of India, Ministry of Health and Family Welfare, February 12, 2021, https://www.pib.gov.in/PressReleasePage.aspx?PRID=1697441.
[7] ₹ = INR = Indian rupee; US$1 = ₹71.37 on January 1, 2020; all currency amounts are in ₹ unless otherwise specified.
[8] "Maternal Mortality Rate."

measures had alleviated the problem, but they had not eradicated it. Despite many improvements, there were still an estimated 26,437 maternal deaths in 2018.[9]

Antenatal care was a key measure intended to reduce maternal deaths. All expectant mothers were advised to register for antenatal care at the nearest health facility as soon as they were aware of their pregnancy.[10] They were also offered eight free monthly check-ups to assess vital health measurements and to identify high risk issues affecting their or their baby's well-being in time for corrective action. Expectant mothers were advised that for a healthy pregnancy, they needed to gain one kilogram in body weight per month. They also learned about healthy behaviours during pregnancy and the warning signs to look out for.

India's vast geography was partially urbanized, but a sizable portion of the population still lived in rural areas. The Indian government had introduced a National Rural Health Mission to set up a network of public health institutions across the country using the hub-and-spoke model, which included sub-centres, primary health centres, and community health centres that functioned as rural hospitals (see Exhibit 2). To improve health outcomes, including maternal health in rural areas, the Ministry of Health and Family Welfare had also set up a network of Accredited Social Health Activists (ASHAs).[11]

ASHAs were trained female community health activists who were selected from villages and were provided training to interface between the community and the public health system. They were the first port of call for any health demands of deprived sections of the population, especially women and children who might find it difficult to access the public health system. ASHAs were expected to facilitate access to services at sub-centres and primary health centres, such as immunization, antenatal care, postnatal check-ups, and supplementary nutrition. They also provided nutritional supplements such as oral rehydration therapy and iron folic acid tablets. ASHAs formed an important link by counselling expectant mothers on birth preparedness, the importance of safe delivery, breastfeeding and complementary feeding, and immunization. As volunteer activists, ASHAs were compensated for their time and effort by the government, but they were not paid an actual salary.[12]

Administratively, the entire set-up in the district, which was a geographic subdivision of the state, was overseen by the District Medical & Health Officer (DMHO), who usually worked out of the district headquarters. The DMHO was responsible for administering the government health administrative system and monitoring results. A monthly presentation was made to the DMHO by an auxiliary nurse midwife, who guided and trained the ASHAs and collected data from them. This data became the input for updating the government portal. All of these efforts had contributed to reducing the rates of MMR across the country, but the changes were uneven. In fact, women in tribal or hilly regions of India actually saw higher rates of maternal deaths due to lack of awareness and access to health care.

[9] "National Health Mission," Government of India, Ministry of Health and Family Welfare, accessed January 6, 2022, https://nhm.gov.in/index1.php?lang=1&level=2&sublinkid=822&lid=218.

[10] M. Bhatia, L.K. Dwivedi, K. Banerjee, A. Bansal, M. Ranjan, and P. Dixit, "Pro-Poor Policies and Improvements in Maternal Health Outcomes in India," *BMC Pregnancy and Childbirth* 21, no. 389 (2021), https://bmcpregnancychildbirth.biomedcentral.com/articles/10.1186/s12884-021-03839-w.

[11] The acronym "ASHA" also meat "hope" or "wish" in India's Hindi language; "Chapter 03: Maternal & Adolescent Healthcare," in Department of Health and Family Welfare, *Annual Report 2017–2018*, https://main.mohfw.gov.in/sites/default/files/03Chapter.pdf.

[12] Government of India, National Health Mission, *Guidelines on Accredited Social Health Activists (ASHA)*, task group report, accessed June 6, 2022, https://nhm.gov.in/images/pdf/communitisation/task-group-reports/guidelines-on-asha.pdf; Additional reference to their compensation: https://www.deccanherald.com/national/asha-workers-the-foot-soldiers-in-indias-battle-to-improve-public-health-1110139.html.

SAVEMOM IS BORN

Wearable devices using mobile applications for health care was not a new concept. Technology devices such as fitness trackers to monitor general health, electrocardiogram (ECG), and blood pressure had been slowly gaining acceptance in various areas. Wearable biosensors and artificial intelligence were helping patients and assisting doctors to monitor health data remotely. Globally, mobile and wearable technology was being used to support maternal health. Senthilkumar's exposure to technology for medical purposes started when he was an engineer at Qualcomm, a global wireless technology giant based in the United States. In 2014, Senthilkumar followed closely the developments of Qualcomm's XPrize challenge, which was won by a team named Final Frontiers Medical Devices from Philadelphia, Pennsylvania. The team had built a device called DxtER, a device that used artificial intelligence to diagnose medical conditions by integrating data from patients with data from clinical emergencies. Using a set of Bluetooth sensors connected to an Apple iPad system and data analysis, the software could detect illnesses such as diabetes and atrial fibrillation.[13]

The novel approach of using technology to detect medical conditions inspired Senthilkumar. Scanning the landscape in India, he identified the greatest need areas as rural India, where expectant mothers had to travel long distances to reach the nearest primary health care centres for antenatal check-ups. In those areas, general awareness of health and nutrition was low, which led to high death rates of mothers and children. Senthilkumar realized that technology could potentially save lives in these areas, but it had to be affordable to a price-sensitive market in rural India for the product to be effective. In September 2016, realizing that no existing devices were currently meeting those needs in rural India, Senthilkumar and his partner founded JioVio Healthcare as a social entrepreneurship venture and developed Savemom as the company's technology product to address the challenges of maternal mortality in rural areas.

The two co-founders visited tribal villages in the southern Indian state of Kerala hoping to interact with expectant mothers and their families to better understand their needs. However, the villagers were resistant to discussing their problems with strangers. But Senthilkumar did not give up. He managed to get permission from a local school to teach interested children science and used practical examples. Soon, up to thirty children were attending his lessons and speaking fondly of Senthilkumar to their family members. Before long, the people in the community began confiding in him, which made him realize that community immersion was more crucial than technology for any solution to be effective.

Among various disturbing stories Senthilkumar and Pandian heard from the local women, one situation had an especially strong impact. A woman was expecting her second baby after having lost her first one in the seventh month of pregnancy. When Senthilkumar and Pandian visited the local health care centre to learn about her first pregnancy, they discovered that her health records were inaccurate. They had falsely recorded a successful birth of the woman's first child, including false details about the baby having been vaccinated and the family having received ₹10,000 from the government's financial assistance program. Her records even included her husband's signature, but Senthilkumar had been told by the family that they had never gone for an antenatal check-up because the hospital was more than 20 kilometres away. It seemed obvious that the report had been falsified and government funds intended to support the pregnant mother and her baby had been misused. Senthilkumar and Pandian decided that something had to be done to rectify the issue.

Determined to find out more details, Senthilkumar approached the local office of the DMHO, whose key goal was to reduce MMR by improving the registration process for expectant mothers and increasing the number of regular check-ups. To support this objective, the DMHO monitored local ASHAs. Senthilkumar

[13] Zina Bacha, "The Dxter Is a Tricorder Sensor that Can Detect Various Medical Conditions," Strammer, November 8, 2018, https://strammer.com/en/dxter; Startrek.com Staff, "Qualcomm Tricorder XPRIZE Winner Announced, Star Trek, April 13, 2017, https://ca.startrek.com/article/qualcomm-tricorder-xprize-winner-announced.

suggested that a technology solution could assist the DMHO in reducing MMR in the region and requested baseline data on expectant mothers in the district for the previous two years.

Senthilkumar was directed to a rural hospital, where an administrator showed him data in a Microsoft Excel file that was updated manually and forwarded to higher levels of government. Senthilkumar could tell that the data was manipulated to make the program appear successful and that the information was inaccurate. Senthilkumar discovered that many of the local expectant mothers were unaware of the government program or that it was intended to provide funding for their well-being, but the data collected about their health could be easily tampered with:

> This was where technology could help in making things better. Our solution had to be zero manual intervention, where the device, or prototype, could directly capture the data. Hence, we built Savemom, a maternal health care product which provided connected maternal care at home using local communities, smart devices, and telemedicine software. It had a Bluetooth-enabled medical device for the ASHAs and a software platform for the doctors and the DMHO.

The Savemom technology allowed ASHAs to access primary care centre data and identify registered expectant mothers. They would then visit patients to gather their information and post it online using the Savemom app installed on their smartphones, which were provided by the Indian government. In regions without Internet, the app would store the data locally until it could be uploaded to the Savemom server. ASHAs would visit patients every two weeks to measure and update vital health function details using Savemom's Bluetooth enabled digital devices, such as the tool Senthilkumar had designed for his sister. ASHAs recorded the patient's weight, ECG, saturation level, body temperature, and blood sugar. Primary health care centre doctors reviewed the data and classified the patients and their pregnancies as low- or high-risk. ASHAs distributed educational materials and iron and folic acid tablets to low-risk patients but accompanied expectant mothers who were classified as high-risk to the nearest hospital for more tests, such as an ultrasound.

Savemom's pilot program started with seven expectant mothers and was later expanded to 240. Most patients were unfamiliar with technology and uncomfortable using smartphone apps, so Savemom made the interface simple and available in many local languages including Hindi, English, Marathi, Tamil, and Malayalam. "We designed the app with a lot of images and buttons to make it visual and intuitive," noted Senthilkumar (see Exhibit 3). The idea was to make the entire process simple for easy monitoring, including the visits from ASHAs, and all manual data entry was eliminated. Clearly the program was expected to be a success.[14]

SURPRISE AWAITS

Before long, however, Senthilkumar was alarmed by the results. "But how could this be possible?" he asked his team. The initial data from the trial was trickling in, but the first few days of data showed identical vital parameters. Unsure whether the issue was technical or human error, Senthilkumar and his team visited some of the patients to find out more. To their surprise, many patients claimed that no one had visited them to record their vital health information. So, why was the software showing their names and medical data? A visit to the health centre at Wayanad revealed that some ASHAs were recording fictional data under the names of actual patients, without ever visiting the expectant mothers, so all data was incorrect. Senthilkumar realized that relying on digital devices was not enough—workers had to be reliable as well.

[14] Of the initial seven patients, two had lost their babies during pregnancy, six were under age sixteen during their first pregnancy, and none had received antenatal check-ups; Divya Krishnan, "SaveMom," March 11, 2019, YouTube video, 3:04, https://www.youtube.com/watch?v=lIEm7xuGels.

Senthilkumar decided that more work was needed to develop the right technology. "This was becoming even more complex. The data had to be captured from the real patient, and that is when we came up with the idea of a wearable device," he said. Doctors were receiving patient information every fifteen to thirty days, but they were hoping to get data on a continuous basis, which would be essential for emergencies.

LAUNCHING ALLOWEAR, ALLOTRICORDER, AND ALLOGATE

Allowear

In 2017, Savemom launched a wearable digital device called Allowear, which resembled a smartwatch with a gold-coloured bracelet (see Exhibit 4). The company believed that an ornamental gold bracelet would make the smartwatch appealing for pregnant mothers in small villages to use. To address the issue of falsified medical information, Savemom redesigned the data collection process to be less dependent on human input. The Allowear device worn by each expectant mother functioned like an automatic health recording and authentication mechanism.

ASHAs were required to visit expectant mothers and connect to their Allowear device via Bluetooth before entering any information manually. ASHAs would then use their smartphone's Savemom app to take a picture of the patient's Aadhaar card, which contained a twelve-digit identification number issued by the government's Unique Identification Authority of India to all residents. The card also contained the patient's name, age, photograph, and address. The ASHA's Savemom app could scan the card and automatically extract all identification information. ASHAs would then ask the patient about health issues or abnormalities, following the app's step-by-step guidance. All steps on the app were clearly shown using images and simple yes or no questions. The patient's Allowear device monitored activities such as calorie consumption and sleep cycle. It also provided reminders for taking medication and when to expect the next visit from an ASHA.

On the ASHA's next patient visit, the Savemom app on the ASHA's smartphone would automatically pair via Bluetooth with the patient's Allowear device and display a picture of the patient as confirmation of identity. The ASHA would then proceed with the rest of the data collection, avoiding any manual data input. ASHAs carried a large medical measurement device in a backpack that could measure the patient's weight, ECG, saturation level, body temperature, and blood sugar. However, the large medical measurement device was heavy, weighing approximately 12 kilograms. In 2018, when Senthilkumar was accompanying an ASHA on her visits in Kasara district of Maharashtra in central India, the ASHA complained that the backpack was too heavy to carry on foot across rough terrain. Some expectant mothers lived in mountainous regions, making the trek considerably arduous and causing ASHAs to become physically exhausted after only a couple of visits.

AlloTricorder

One of the ASHAs suggested to Senthilkumar that Savemom create a lighter version of the medical measurement device that would be smaller and easy enough to carry in a handbag. This would allow ASHAs to visit more patients in different locations. The Savemom team worked on a redesign of the medical measurement device and created a new version small enough to carry in a handbag (see Exhibit 5). The new version of the medical measurement device was called AlloTricorder. ASHAs were pleased with the improved version of the device, which would make their work far more efficient. ASHAs would pair the device via Bluetooth with the Savemom app on their smartphone or tablet, which was provided by the Indian government, and efficiently capture the patient's data using the compact medical measurement device.

Allogate

Although ASHAs captured vital health information only during their visits, and expectant mothers only saw a doctor if there were issues, Savemom's technology ensured that patients remained connected with doctors. Savemom created a teleconsulting online platform called Allogate that digitally sent all patient data collected by the ASHAs directly to the doctors. The Allogate platform provided doctors with all the data they needed to identify any changes in the patients that might require medical intervention. Doctors would receive the patient's health information and quickly identify any high-risk cases, which usually consisted of 8–10 per cent of all expectant mothers.

ASHAS

Most ASHAs were hard-working and eager to help expectant mothers. Their job was physically difficult, requiring travel across various villages on foot to visit patient's homes and capture their health information. In addition to providing health services to expectant mothers, ASHAs also served as health and welfare advisors for rural women. Their tasks, which varied considerably, included convincing parents to send children to school. Some ASHAs confided in Senthilkumar that they had started their work with great enthusiasm but were sometimes cautioned by more veteran ASHAs to avoid supporting what they found was a faulty system, with little reward for their hard work. Senthilkumar empathized with the ASHAs and understood their concerns. He was told that ASHAs were only offered government compensation of a maximum of ₹2,000 per month, regardless how many hours they worked.[15] In comparison, they had heard that each expectant mother was given up to ₹10,000 for health care expenses, which made ASHAs feel that their efforts were not highly valued by the government.

The ASHAs that spoke to Senthilkumar seemed somewhat dismayed and resentful. Senthilkumar decided that to effectively address the high MMR in India, ASHAs needed to be better compensated. He persuaded the DMHO to agree with his viewpoint and a new financial incentive plan was introduced, giving ASHAs an additional per visit amount for each successful delivery. Earnest ASHAs could now earn approximately ₹4,000 per month.[16] As a result, motivation levels increased drastically, with many ASHAs eager to travel beyond their allocated area. Senthilkumar saw the change as a major improvement. "It was a huge motivator. It was also a transparent system now, and that works."

MORE SETBACKS

Just when the Savemom team was beginning to see great results from their work, new data abnormalities were noticed. The data showed that many expectant mothers were travelling more than 25,000 steps each day. The data implied that they were sometimes even jogging, which was a dangerous activity for an expectant mother living in hilly rural regions. The ASHAs advised the family members of their patients to stop burdening the expectant mothers with heavy work, but the data pattern persisted.

During some routine visits, the team discovered that some patients were not wearing their Allowear device at all. In fact, some husbands of patients who saw the device as an attractive accessory had decided to wear it as a bracelet, causing incorrect data to be recorded. In other cases, some patients were reluctant to wear the Allowear device because of its highly appealing appearance, as one expectant mother confessed: "My

[15] Anuradha Raman, "At the Forefront of India's Healthcare System, ASHA Workers Soldier On—Unprotected and Poorly Paid," *The Hindu*, July 4, 2020, https://www.thehindu.com/society/at-the-forefront-of-indias-healthcare-system-asha-workers-soldier-on-unprotected-and-poorly-paid/article31979010.ece.
[16] Raman, "At the Forefront of India's Healthcare System."

husband didn't take it, but it looks like a luxury watch, and if I go outside wearing this, it draws too much attention. I was feeling annoyed. So, I only wear it inside the house." Overall, the Allowear device was fraught with issues. Yet again, the Savemom team was forced to consider redesign options for the device to be suitable for expectant mothers to wear at all times—both inside and outside their homes.

After meeting with women from different villages in Maharashtra and Kerala, the Savemom team found that most of them wore beads that resembled a religious rosary necklace, which they called *tulsi mani parse mani*. Almost all women in the villages wore the beads on their wrist, around their necks, or on their feet. One of the women told Senthilkumar that if the Allowear device could possibly be designed in such a form, which was unappealing to the husbands, all women in the villages would wear it.

Senthilkumar realized that the woman was right and that her idea might just work. The team confirmed the widespread use of the beads by walking around the villages, and then resumed their work to build yet another improved version of the Allowear technology—this time so small that it could fit inside a bead. The team also made the batteries for the device last six to nine months, which would not need recharging for the entire pregnancy period. The new design was also waterproof, making it unnecessary to remove. With the device's sensor, Bluetooth module, and batteries all in the shape of beads, the patients would feel like they were simply wearing their bead bracelets and necklaces (see Exhibit 6). The new design of the Allowear device was tested on expectant mothers and was found to be working perfectly, with the correct health data being recorded. Senthilkumar was pleased with the results. "The current design of Allowear was an outcome of multiple iterations. It was clear that technology itself could never be the solution in such situations. Social [family and community] and cultural aspects were also a critical part of the success of products like Savemom."

IMPACT AND DISTRESSED DOCTORS

Senthilkumar's happiest moment in his venture's journey was when he received an invitation from the villagers and, without knowing what to expect, a healthy and a smiling baby that was born in the village was placed in his arms (see Exhibit 7). It was a great honour for Senthilkumar to see the ultimate reward of the Savemom venture and the outcome of his social entrepreneurship journey. According to his research, Senthilkumar found that the average weight of babies whose mothers used Allowear was 40 per cent higher.

By early 2020, the Allowear pilot project seemed to be working well. ASHAs provided the Allowear device to each registered expectant mother on the first visit and told the patient to wear the device at all times. The device would be paired with the ASHA's app on a smartphone or tablet at each visit and all data would be automatically recorded. ASHAs were also provided with incentives to report the data correctly. In Kerala alone, around 1,862 expectant mothers took part in the pilot project, which identified 317 high-risk patients and supported the successful delivery of a baby for 1,452 mothers. The average weight of the babies in the project had increased to 2.9 kilograms, from the previous 2.1 kilograms. More than 1,000 Allowear digital wearable devices and approximately 100 AlloTricorder portable medical measurement devices were deployed as part of the government's initiative and budget for maternal care in rural areas.

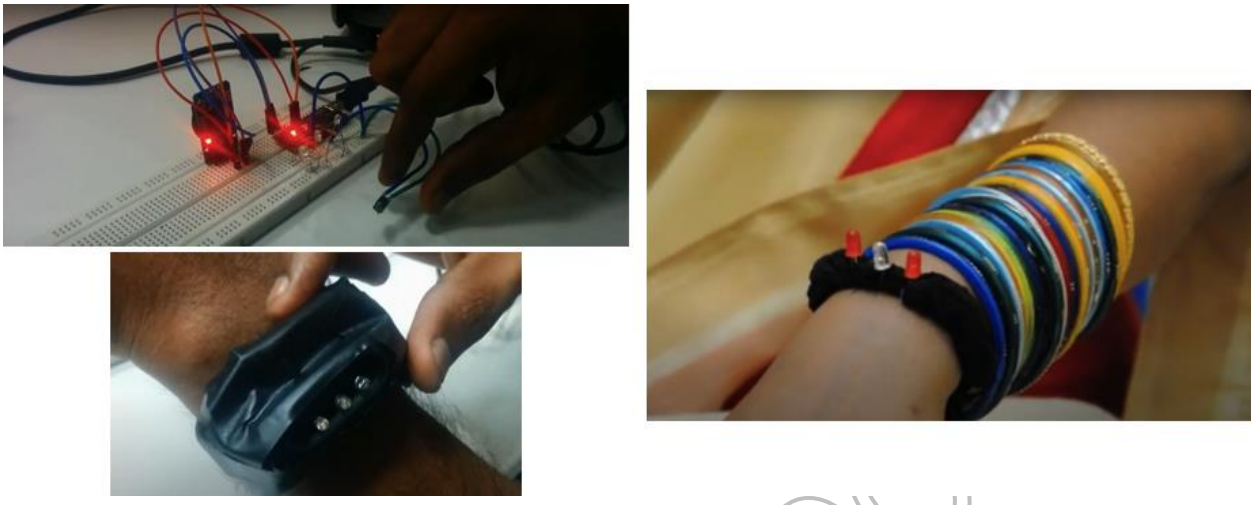
The major steps in the process seemed to be operating as planned. During their routine patient visits, ASHAs registered and captured data for expectant mothers. The data was then shared with a nearby doctor, who provided feedback the next day. On the third day, the ASHA visited the patient to distribute nutrition tablets prescribed by the doctor or to inform the expectant mother to see a doctor.

That was why Senthilkumar was surprised to find disgruntled doctors upon his visit. They claimed that their workload had increased from seeing twenty to thirty patients per day to reviewing medical data for more

than 300 patients each day with the new technology. And they still had to provide care to all other patients. Doctors were finding it difficult to keep up with the high volume of data coming in, which was resulting in delayed responses or no response at all.

After the many iterations and problem solving over the previous two years, Senthilkumar was disheartened to hear the bad news. Despite building the Allogate platform to assist doctors with the teleconsulting process, they were dissatisfied with the results. Senthilkumar was sympathetic to the concerns expressed by the doctors. A way to resolve the issue and make the doctors' job more efficient had to be found.

EXHIBIT 1: FIRST SAVEMOM PROTOTYPE



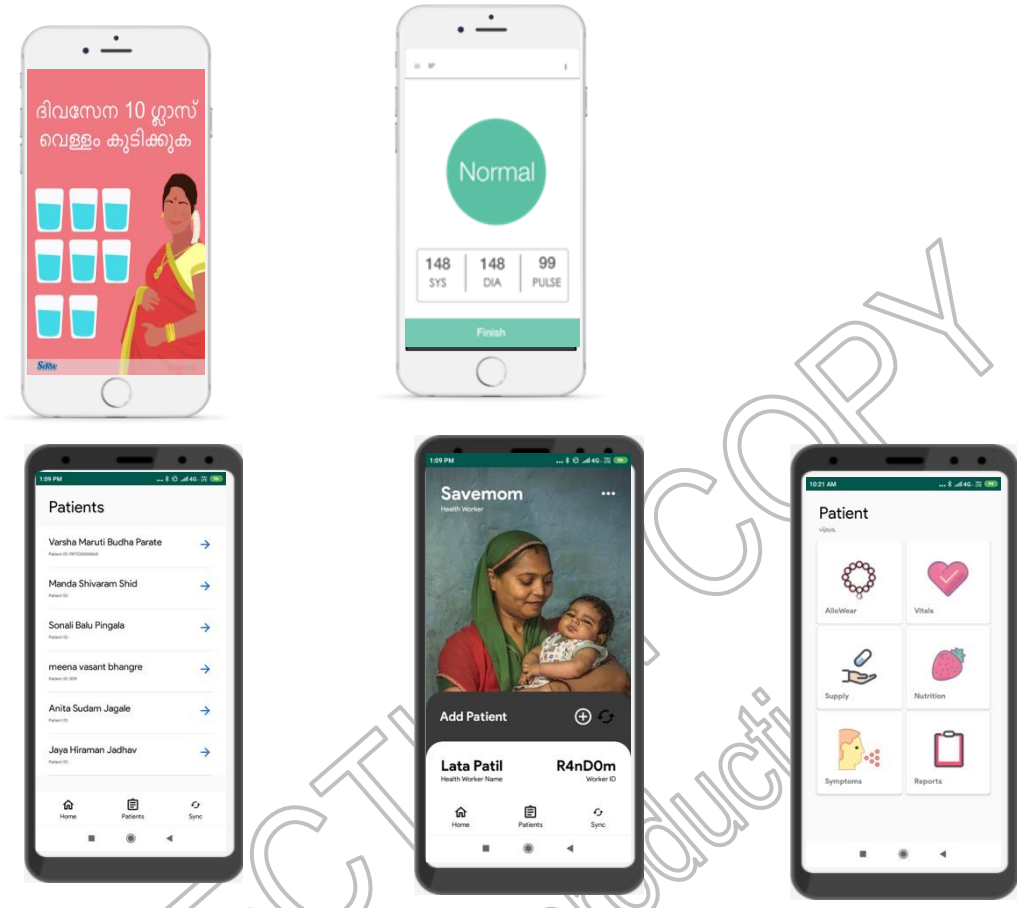
Source: Images provided by the company; more information available at senthil kumar, "SaveMom—Smart wearable for Pregnant women," June 5, 2016, YouTube video, 2:31, https://www.youtube.com/watch?v=RjOdmsoxYps.

EXHIBIT 2: STRUCTURE OF THE RURAL HEALTH CARE SYSTEM IN INDIA

Centre	Plain Area	Hilly, Tribal, Difficult Area	Staff Members
Sub-Centre	5,000	3,000	Staff includes at least one auxiliary nurse midwife or female health worker and one male health worker. It provides basic drugs for minor ailments needed for taking care of essential health needs of men, women, and children.
Primary Health Centre	30,000	20,000	This is the first contact point between a village community and the medical officer. It is supported by fourteen paramedical and other staff. It acts as a referral unit for six sub-centres and has four to six beds for patients. Activities include curative, preventive, promotive care, as well as family welfare services.
Community Health Centre	120,000	80,000	Staff includes four medical specialists (i.e., surgeon, physician, gynecologist, and pediatrician) supported by twenty-one paramedical and other staff. It has thirty indoor beds with operation theatre, X-ray, labour room, and laboratory facilities. It serves as a referral centre for four primary health centres. It also provides facilities for obstetric care and specialist consultations.

Source: Government of India, National Health Mission, *Rural Health Care System in India*, accessed June 6, 2022, https://www.nhm.gov.in/images/pdf/monitoring/rhs/rural-health-care-system-india-final-9-4-2012.pdf.

EXHIBIT 3: SAVEMOM INTITUTIVE USER INTERFACE



Source: Company documents.

EXHIBIT 4: ALLOWEAR DEVICE—A JEWELLERY INSPIRED GOLD BRACELET

Source: Company documents; Senthil Kumar, “Med4dev_Challenge#4_Teamlotronic,” July 24, 2016, YouTube video, 2:47, https://www.youtube.com/watch?v=yNe4rvQki6M.

EXHIBIT 5: ALLOTRICORDER DEVICE—HEALTH MEASUREMENT DATA RECORDED AND SENT

Note: ECG = electrocardiogram; SMS = short message service; USB = Universal Serial Bus; app = digital application
Source: Company documents.

EXHIBIT 6: ALLOWEAR SMART WEARABLE DEVICE AS BEAD NECKLACE OR CHAIN

Source: Company documents.

EXHIBIT 7: SENTHILKUMAR MURUGESAN HOLDING A HEALTHY NEWBORN BABY

Source: Company documents.