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Designing Cloud-Based Functionality for a South African Milk Bank During the Covid-19 Pandemic

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ABSTRACT

Human breastmilk donation is not a widespread practise, and thus creating a positive and motivating donation experience is important in order to retain those who do choose to donate. *Milk Matters*, a human breastmilk bank, previously hosted a mobile application aimed at improving the donor experience. However, this application consisted entirely of hard-coded content, and so quickly became out of date. In this study, we detail the design of a replacement software suite, consisting of a donor-facing application and a staff-facing application. Key to this design is the implementation of cloud-hosted services, including a database and an authentication system. This system is designed using a co-design process, modified to eliminate any in-person contact (due to the ongoing COVID-19 pandemic). We find a demand for several features, such as a donation tracker, and discover several important non-functional requirements for the backend system stemming from *Milk Matters'* status as an NGO. Based on our findings, we motivate the could-based functionality of the system, as well as the design of the cloud-based backend systems. Additionally, we find the remote co-design process to be repeatedly impeded by technical difficulties, but also benefitted by the easy scheduling of online video meetings.

1 INTRODUCTION

Milk banks fill an important and often overlooked role in our modern healthcare system. By working to allow both the donation and storage of human breast milk, they are able to help cater for those mothers who, for some reason or another, are unable to produce enough milk for their child. However, despite this important function, human breast milk donation is still a relatively unpopular activity, especially when compared to other common forms of donation, such as blood. As such, it is more important than in most other fields that new donors be recruited, and current donors maintained.

In this study, we worked with a Cape Town based human breast milk bank by the name of *Milk Matters* to develop an application with the intention of improving the donor experience, as well as allowing for easy registration as one. This work represents a continuation of a project started previously by Wardle et al. [21,22] Here, a co-design process was developed and used to design a mobile application with much the same goal. Milk donors are a relatively unresearched demographic, especially in a South African context, and so this project also aims to continue Wardle et al.'s work in building an understanding of this group.

A crucial difference between the two applications is their connectivity: the original application was entirely static and contained only hard-coded content. Our application, in contrast, makes full use of a backend system to allow for the updating of in-app content, as well as other features convenient to both *Milk Matters* and their donors. However, this added functionality brings additional considerations that need to be addressed when designing for a relatively small non-profit organization such as *Milk Matters*. This project was divided between 3 researchers (as detailed in Appendix A), with my portion focusing on the design and implementation of the cloud-hosted backend. As such, this paper focuses on the design of this backend system specifically, alongside the new functionality that takes advantage of it.

The research conducted during this study occurred during, and was impacted by, the global COVID-19 pandemic. Many aspects of co-design that would otherwise be taken for granted, such as in-person interaction with participants, were rendered unfeasible due to safely concerns. In response to these challenges we formulated and executed a completely remote co-design process, based off the previous work of Wardle et al., heavily utilizing video-conferencing software and online prototyping software. [21,22]

In this paper, we first recount Wardle et al.'s previous work with *Milk Matters*. We then detail the methods used by us in our studies and justify our choices where necessary. After this we detail several functionalities present within the final applications that take advantage of the new backend system, following which we will provide the results of our study. Finally, we will analyze these results, and use them to motivate both our previously mentioned design and the design of the backend itself. We will also discuss several aspects of our remote approach to co-design.

2 BACKGROUND

2.1 Milk Donation

Milk donation is ultimately a recourse for mothers unable to supply enough milk themselves to their infants. It is not the only available alternative, however: milk formula is often used by mothers to supplement their milk production where needed, and

sometimes replaces breast milk entirely [3]. However, many medical boards recommend breast milk over other alternatives, including the *European Society for Paediatric Gastroenterology Hepatology and Nutrition* (ESPGHAN) [2]. Breast-feeding (and by extension breast milk) has been found to reduce the risk of diarrhea, prevent infections, and improve cognitive development in infants, among other benefits [3]. Furthermore, research suggests that the use of formula (in lieu of breast milk) when feeding preterm infants can result in a higher risk of contracting NEC (necrotizing entero-colitis) [10].

2.2 Milk Matters

Milk Matters is a South African nonprofit organization specializing in the collection, storage, and distribution of human breast milk [12]. Operating in the Western Cape, *Milk Matters* focuses on supplying breast milk to hospitals, particularly to premature babies. While initially supplying older babies in an orphanage, they pivoted to premature births, stating: "Rather than use 1 liter of milk to feed just one 7kg baby for 1 day, that same liter of milk could feed 21 premature babies of less than 1kg for 24 hours each –and very likely save their lives." [12]

Milk Matters is a relatively small-scale operation, with only about 20 donors contributing milk at any time [22]. Additionally, the organization is only composed of about 5 staff members: a nurse, a dietician, a lactation consultant, and 2 additional support staff [22]. Milk donors tend to be short term, partly due to their window of breastmilk production ending but also due to a loss of interest. Donors often feel frustrated by the lack of feedback associated with their donations, and often do not realize just how important their donations are. In fact, one of the goals of the 2018 UCT collaboration was to provide some additional form of feedback to donors about their donations [3].

Despite this, Milk Matters boasts a relatively large base of invested non-donors. They have an e-mailing list of 1016 members, made up of a mixture of previous donors, supporters, and other interested parties [22]. Additionally, this mailing list currently represents Milk Matters main form of communication with its base.

2.3 Past Work with Milk Matters

In 2016, Wardle et al. published "Exploring Co-design with Breastfeeding Mothers", representing the first instance of cooperation between the University of Cape Town (UCT) and Milk Matters [21]. To explore design with this little-researched group, the researchers decided to collaborate with Milk Matters in designing an application to help donor mothers. The researchers developed an application with 3 main features: an individual milk-donation tracker for each mother, a milk-drop off depot locator, a breastfeeding-topic screen, and a general motherhood-topic screen [21]. However, all features in this first application were implemented as static content, entirely self-contained to the local application data itself. This made the application's content incredibly hard to update and resulted in it quickly becoming out-of-date. In addition, the application only supported the *Android* operating system, resulting in many donors being unable to use the application due to owning *iOS* devices.

For Wardle's thesis, she pursued the implementation of a donor chat room within the pre-existing application [22]. Unfortunately, this was never properly incorporated into the existing application. This was because *Milk Matters* were worried that a chatroom would allow the spread of misinformation, which they felt they would ultimately be held liable for [22]. They also were worried about the additional manpower required to moderate a chat room.

3 RELATED WORK

3.1 Currently Understood Milk Donor Motivations

During their research with Milk Matters donors, Wardle et al. noted the mothers claimed that altruism was a strong motivator towards their decision to donate breast milk [21]. This motivation has been corroborated by other studies [7]. Additionally, mothers stated that they were motivated by testimonials and success stories relating to milk banking, particularly those about the recipients of the milk [21]. Finally, the mothers stated that positive reinforcement about their donations played a strong role in encouraging them to continue donating [21]. In fact, some mothers stated that they disliked donating to milk banks due to the lack of feedback associated with donating to them, preferring instead to stick to informal peer-to-peer donation networks [6].

3.2 Co-Design

Co-design refers to the practice of having trained application designers participate with potential users in designing a product and is defined by Sanders and Stappers as "the creativity of designers and people not trained in design working together in the design development process."[15] This method of design is distinct from "co-creation", which simply refers to any act of creativity stemming from the collaboration of two or more designers. This contrasts with classical design theory, in which the line between designer and user is strict and unbroken: Classical design treats the user simply as an object of study [15]. "Co-design" usually takes place at the very beginning of a product's design and is used to define the key deliverables expected from it. After these are decided upon, a more traditional design process ensues, with designers crafting a product that meets these criteria. Compared to classical design, Co-design possesses a few key advantages. The most plainly obvious is that, by integrating feedback from a userbase early in the design process, a project's functional and non-functional requirements will more closely align with what the userbase desires. This process has been found to result in more successful innovations in product design, particularly with regards to service design [18]. Additionally, co-design is associated with overall better decision making, lower development costs, and a quicker time-to-market.

Many projects utilizing co-design are incredibly reliant on methods requiring in-person contact, such as workshops and physical interviews [16,20–22]. While this largely stems from ease-of-organization and tradition (e.g.: workshops have

traditionally been done in person, so many of them continue to be hosted as such because it is what most are comfortable with), another more fundamental reason is the ease at which this implementation allows for observation and facilitation. In co-design, it is imperative that the researchers facilitate users' creativity and insight, as well as make note of it [15]. These roles are simply easier to complete in-person, as researchers can physically intervene either to help facilitate users, or to improve their ability to observe.

Wardle et al. used co-design in their initial work with mothers. However, they did encounter some difficulties in doing so. For instance, the researchers found that their interviews with mothers would often be cut short by distractions stemming from their children [21]. This would often cut the flow of the interview, resulting in the mother forgetting what they were talking about. Additionally, it was often difficult to schedule these interviews at a time that was convenient for the mothers, as most of their day would be devoted to looking after their child. These limitations, ultimately, lead to the scrapping of plans for larger workshops, and instead individual interviews became the focus. These issues were also experienced by Gibson and Hanson in their studies with mothers [5].

3.3 Cloud Hosting

The *National Institute of Standards and Technology* (NIST) defines cloud computing as: "…a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction." [11]. These services have seen immense popularity over the last few years due to several factors, chief among them being the relatively low financial costs associated with them [19]. Non-profits, in particular, are often challenged by the need to fund their own Information-Systems infrastructure and are usually find it difficult to budget for adequately [19]. However, there are several aspects associated with the cloud computing paradigm that are uniquely suited towards use by non-profit organizations: it's relatively cheap costs coupled with the fact that one does not need to invest in the purchasing and maintenance of additional hardware make it an ideal solution to this problem. Additionally, some cloud providers offer discounted services to non-profit organizations. While lower costs are certainly an advantage, "…the benefits to nonprofit staff members may include 24/7 access to organizational data and software tools, solutions that conform to industry standards (e.g., CRM), and a richer environment for staff collaboration."[19].

4 METHODS

4.1 General Approach to Research Under the COVID-19 Pandemic

This project was initiated just as the South African COVID-19 pandemic response was instituted[1]. This required us to adapt our research methods to accommodate not only the ethical concerns related to operating under the pandemic, but also the very real legal guidelines in place at the time. As a result, our research plans were entirely remote in nature, which is in of itself an oddity in the Human Computer Interaction research space.

Much of our research plan relied on the use of videoconferencing technology. This allowed us to safely conduct on-on-one interviews with participants without relying on in-person contact. We hypothesized that teleconferencing would allow for more-easily scheduled interviews, as it would not require either party to travel to attend a meeting. Additionally, when scheduled in advance with a set time duration, video calls tend to be more strictly structured timewise than in-person meetings [17]. We expected this to work to our favor, as it would hopefully result in interviews that were both easier to parse after the fact, and more likely to remain on-time.

We decided to utilize *Jitsi Meet*[2] as our videoconferencing platform. This choice was made due to its incredibly lightweight nature: unlike many of its competitors, *Jitsi Meet* does not require users to register an account to use it. Additionally, it operates entirely through one's web browser, and does not require the downloading of any software. Finally, it allows for any meeting to be password-gated, allowing for a high level of security. These three aspects ensured that the tool was easy to use, guaranteed to work on any computing device, and secure enough for our purposes. It should be noted, however, that teleconferencing is not a one-to-one replacement for in-person interviewing. Compared to traditional face-to-face meetings, teleconferencing does not have a completely identical "flow" of conversation. Often, breaks in connectivity can result in disruptions, either due to gaps in communication from one party, or delays in transmission from one party resulting in overlapping speech [14].

All interviews were video recorded, with the participant's consent, using *Open Broadcaster Software*[3]. This allowed us to re-examine previous interviews easily, as well as allow researchers that were not present for interviews to experience them after the fact.

The interviews were conducted in a semi-structured manner, with the interviewers all reading off the same list of questions but still possessing the freedom to go "off script" if they judged a new avenue of discussion to be interesting enough. For each interview, at least two researchers were present. One took the role of the

[1] https://www.tralac.org/news/article/14617-south-africa-s-policy-response-to-the-covid-19-pandemic.html
[2] https://meet.jit.si/
[3] https://obsproject.com/

interviewer while another took the role of a transcriber. Since the interviews were also being recorded, the transcriber could check their notes against the recording afterwards to make sure it accurately represented the interview.

In addition to videoconferencing, we utilized an online survey to solicit responses from a wider audience than we could feasibly reach with interviews. Overall, surveys are generally more "quantitative" than traditional interviews and are most effective when utilized to research an entire population [9,13]. In their earlier work, Wardle et al. had difficulty in soliciting replies to their distributed surveys [21]. As such, we made a conscious effort to minimize the use of surveys, resulting in us only accounting for a single survey in our plans.

All qualitative data gathered was examined using "grounded theory" [1,4]. This process entails the generation of "grounded theories", which are used to better understand our user's needs, positions, and opinions. To build these theories, a thematic analysis was conducted on all our interview transcripts through the process of collaborative tagging and coding.

4.2 Stage 1

Stage 1 of the research process was mainly intended to function as both a recruitment process and a general inquiry into both the donor population and the *Milk Matters* staff body. We planned to distribute a survey to as many *Milk Matters* donor mothers as was feasible, alongside invitations to participate in the interviews that would ultimately make up the bulk of the research. This survey would be the only one associated with this project, and was designed to generate a broad, general understanding of the donor's attitudes towards web-content in the context of breast-feeding. Additionally, questions asking about each donor's preferred social media platforms would be included, allowing us to target the most popular ones for integration with the final application.

While the survey was only distributed to donors, both staff and donors were invited to participate in the interviews. Participants who accepted our interview invitations were asked to provide us with times and dates during which they could meet. By placing the onus on the participants to supply a time for the meeting, we ensured that the meetings would be scheduled at a time that was convenient to the participants. This was especially important for the donor mothers, as they often have very little free time, in-between caring for their children and completing other tasks [21].

For our survey, we received in total only seven responses. Some of these responses came from mothers who would later take part in interviews, resulting in similar views coming through in each. The survey and the stage 1 interview both shared some questions, to account for mothers who only participated in the interviews and not the survey or vice-versa.

The purposes of the interviews differed between the donors and the staff. For the donors, the questions asked mainly aimed to understand what motivated them to donate to *Milk Matters,* and their history with the organization. Additionally, we aimed to survey their smartphone and social media habits, as well as their personal milk donation process. Finally, we also aimed to discover what personal information they would be comfortable sharing with *Milk Matters* through the application.

We initially allocated two weeks for donor recruitment and initial interviewing. At the beginning of this period, a general email was sent out to all current donors, containing a link to the survey and an invitation to participate in the one-on-one interviews. However, we did not receive any volunteers for the interviews within the first week, resulting in *Milk Matters* offering to refer us to several donors directly whom they thought would be interested in partaking. This process bore fruit, and we were able to secure four volunteers for the interview process towards the end of the second week.

When interviewing the staff members, our questions were instead geared towards the actual running of *Milk Matters*, particularly with regards to their current strategies for donor engagement. We also aimed to gather information about the individual's work routine with *Milk Matters*, as well as their history with the organization. We planned to go over the functionality of the previously developed application with them, to gauge whether it was all still relevant. Finally, we asked them questions with the aim of explicitly gathering some non-functional requirements related to the project (e.g.: would *Milk Matters* have the budget to afford webhosting).

For the staff-centered interviews, we were able to recruit two staff members to participate. Despite this small number, they represented over half of the current *Milk Matters* staff, and so could be trusted to represent the organization. One of the participants was in fact the CEO, and so was able to provide definitive answers relating to the overall operating procedure and structure of *Milk Matters*.

4.3 Stage 2

Using the results from Stage 1, the researchers designed two "paper prototypes" with the intent to use them for a usability evaluation with the same participants as before: one to represent a donor-facing mobile application, and one to represent a staff-facing application. Paper prototypes are traditionally used early in the design process, as they allow for the quick iteration and development of the design [8]. Usually, these consist of numerous physical drawings representing the application, manipulated by a human "computer" to simulate it running on a device. Paper prototypes are also valued for their perceived "roughness": as they are visually not complete, participants are more likely to question fundamental aspects of the design.

We were unable to use a paper prototype in its traditional form, owning to the remote nature of our interviews. We ultimately decided to use *Moqups*[4], an "online mockup, wireframe & UI prototyping tool". Despite the high-fidelity that this software was able to support, we decided to deliberately keep our prototypes

[4] https://moqups.com/

visually basic to mimic the roughness of a traditional paper prototype.

Unfortunately, due to a lack of float-time in the schedule devised by the researchers, the delay in acquiring donor participants in stage 1 resulted in those interviews occurring during the prototype design period. As such, these prototypes were largely designed without donor feedback from stage 1 and so were skewed towards functionality suggested by the staff stage 1 interviews, which were completed earlier in the schedule.

In terms of the usability evaluations, we ran the prototype on the interviewer's side and shared that screen over the meeting with the participant. The participant would then proceed to verbally instruct the interviewer as to what actions they would take on the prototype, and the interviewer would carry it out. While *Moqups* contains functionality that would allow for the prototype to be run directly on the user's side, this was decided on instead in order to allow for the interviewer/computer to step in and "fix" any issues with the prototype that arose.

Two separate sets of usability evaluations were carried out: one with the staff participants that focused on the staff-facing application, and another with the donor participants that focused on the donor-facing application. Both followed roughly the same structure, with the participant being asked to complete a series of tasks using the prototype, and then being asked questions about their experience afterwards. These questions were designed to evaluate both the prototype, and the digital usability evaluation experience itself.

4.4 Stage 3

The final deliverable was designed and developed using the feedback received from Stage 2. Stage 3 consisted of a final round of wrap-up interviews with all participants. Much like Stage 2, the interviews took the form of a usability evaluation. However, this time development versions of the final applications were evaluated. These were, once again, run on the researcher's side and shared using *Jitsi Meet's* screensharing functionality.

The tasks given to the participants were largely similar to those found in stage 2, only adjusted where the functionality had changed since the prototypes. Finally, several post-evaluation questions evaluated non-functional requirements that were not tested for in the prototype, such as the applications' font sizes and colour schemes. The remainder of the questions aimed to gauge the participants' thoughts on the final applications, as well as the remote co-design process as a whole.

Additionally, *Milk Matters* staff were given a demonstration of the donor-facing application and asked some questions about it. These interviews aimed to determine whether both applications were accessible to use, and whether their final functionality met the intended needs of the participants.

5 DESIGN

5.1 Backend-Reliant Functionality

The final product was envisioned as being made up of two distinct applications: a donor-facing application, intended for use by both registered donors and potential donors, and a staff-facing application, intended to allow for the easy administration of the donor application (See Appendix C). The donor application would take the form of a mobile application, supporting both the *iOS* and *Android* operating systems. The staff application, on the other hand, would be implemented as a web-application, optimized for desktop viewing. Documentation for both can be found at the URLs provided in Appendix D.

When designing the donor app, we aimed to maintain, in some form, all the functionality offered by the initial application developed by Wardle et al [21]. These features have already been vindicated by the previous study and based on our interviews with donors were still desired. Additionally, due to the delay we experienced with the first donor interviews, we were forced to design our initial prototype without new donor input. As such, the decision was made to include, wherever possible, already-proven "safe" features.

For the purposes of this paper, we will be focusing on functionality that directly leverages the newly implemented backend system.

5.1.2 Depot Locator

The new Depot Locator on the donor-facing application fetches a list of depots stored in the database and, using *Google Maps* integration, displays these locations on an actual map of Cape Town. Users can either select their nearest depot, of browse a list of all available depots. This list can be edited by *Milk Matters* using the staff-facing application, allowing for a constantly up-to-date list of depots to be maintained. Each depot has a "description" field, intended to contain depot-specific information such as opening times.

5.1.3 Donation Tracker

The donation tracker returns in a similar form to what was found in the previous application. Present in the donor-facing application, this functionality allows any user to track their donations by recording them in a digital "notebook". Users are able to specify the donation date and the amount donated. They are then able to view their past donations, both as a list ordered by date of donation, or as one of two graphs: one representing the milliliters donated against time, and another representing 50ml feeds donated against time.

5.1.3 Donation Dropoff Declarer

Registered milk donors can, at any time, use this function on the donor-facing application to declare to *Milk Matters* that they have dropped any of their previously tracked donations off at a depot. This will be posted to the application's database and will be

visible to *Milk Matters* staff through their own application. Staff members can then clear donations from the database once they have been collected. In addition to saving time for the donor, this feature also provides the mother with instant feedback after drop-off, as their donations on the donation history page are now marked as "dropped off".

5.1.4 News Feed and Educational Articles

Any users of the donor-facing application can access both a news feed and a collection of educational articles. Both features are implemented in a similar manner, fetching their content from the application database, with the main difference being that educational articles are grouped by categories, while news items remain ungrouped. This content can be updated using the staff-facing application, with any changes automatically being distributed to users of the donor-facing application. All news items and educational articles can be shared to various social media platforms.

5.1.5 "Suggest an Article" Option

Found on the donor-facing application, this function allows registered donors to suggest to *Milk Matters* articles for inclusion as an educational article. These suggestions can be viewed at *Milk Matters*' leisure from the staff-facing app and can either be dismissed or approved. This moderation is much more manageable since it can be completed at any time and consists of a simple decision. Additionally, this function allows for the educational articles collection to be essentially crowdsourced, lessening the work for *Milk Matters.*

5.2 Application Security

Before users begin using the donor-facing application, they are required to register an account with it. This account is used to determine whether the user is a registered donor or not, and by extension whether certain functionality is available to them or not. It is also used to identify uploads to the database when performed using the functions that require it.

It was deemed that certain functionality, namely the Depot Locator, the Donation Dropoff Declarer, and the 'Suggest an Article" option, should be restricted to registered donors only. This is because, in the case of the first two, *Milk Matters* considers depot locations to be sensitive information. In the case of the last one, the choice was made to limit the possibility of spam being submitted. In the previous application, this information was hidden behind a hardcoded password, that was distributed to donors when they registered. While this worked in theory, the security offered by one, immutable password would be broken as soon as said password was leaked. Instead, we devised a system to ask donors to input their own donor number to access these sections of the app. This number is already something that many donors know off the top of their heads, and that is only really known by *Milk Matters* and the donor themselves. Additionally, each donor's number is already unique to themselves, and in our system the donor number will only be accepted if it is associated with the current logged-in donor. This system effectively implements a unique personalized password for every account that does not need to be separately disclosed to said donor. It was decided that, since the regular login system was designed to remember the current user after their first login, these security checks would be encountered every time one needed to access these functions. This is to ensure that, even if someone other than the registered donor access their phone and reaches these screens, they will still be blocked by the security check. During the stage 2 usability evaluations, users were initially confused and frustrated by these checks. However, when the purpose of these checks was explained to them, their attitude towards them shifted to a sense of understanding. Thus, every security check contains text explaining why the security check exists and asking for the user's patience.

6 FINDINGS

6.1 Donation Tracking

Most participants were not currently tracking their donations but expressed a strong desire to. One donor that did at some point engage in tracking stopped because it was incredibly difficult to maintain as it quickly became tedious. Interestingly, according to a survey response at least one donor still uses the original application to track their donations, suggesting that the digital implementation was adopted by some. While this all points towards a desire for some form of donation tracking within the donor-facing application, this is with the stipulation that it is relatively quick and easy to use. During the stage 2 evaluations, all donors stated that their favorite feature showcased was the enhanced donation tracking.

Both staff members expressed a desire to leverage data collected through the application in ways that would make their own jobs easier and more efficient. For example, currently *Milk Matters* directly contacts their depots in order to determine whether there is any milk available for pickup. If donors were tracking their donations to *Milk Matters* through the mobile app, analyzing this data in order to determine which depots have milk would streamline the process incredibly and allow for less confusion overall.

6.2 Social Media Use

By and large, the donor interview participants fell into the same pattern as the survey responses with regards to social media use: *Facebook* was the clear favorite, with every participant following *Milk Matters* on the platform. While some of the donors did have an *Instagram* account, most of them did not follow *Milk Matters* on the platform, as the general understanding was it would contain the same posts as the *Facebook* page. This aligns well with the approach towards social media taken by the *Milk Matters* staff, which considers *Facebook* to be their "central" social media platform. Posts made to their *Facebook* are automatically shared to their *Instagram* as well, resulting in duplicate posts between the two. In terms of the application, this points to any social media integration needing to cater to *Facebook* first, and *Instagram* second.

6.3 Donor-NGO Communication

In general, most communication with *Milk Matters* occurred either via email, or via *WhatsApp*. While there did not seem to be much communication with *Milk Matters* post-registration, multiple donors did message *Milk Matters* after dropping off a donation to inform them of it. *Milk Matters* staff both considered their main communication platforms with donors to be Email and *WhatsApp*. One of the staff members expressed a desire to consolidate their communications to a single platform, as they found the current system complex.

6.4 Sensitivity Towards Donors

One of the most important and consistent themes that emerged from these conversations was the need to remain sensitive to donors of all amounts. The staff from *Milk Matters* were keen to stress that, whatever functionality was implemented, it should not allow donors to compare their donation amounts with each other, whether that be from the app itself or from other donors. Different donors' express breastmilk at different rates, but every drop is valuable and appreciated. Due to this, it was decided that the donor-facing application would not allow donors to view other donors' donation amounts in any capacity. Additionally, while many donors expressed a desire for some form of in-app "chatroom", we were unable to develop any functionality that allowed for this while guaranteeing sensitivity towards donation amounts.

6.5 Security of Sensitive Data

Additionally, another key theme that emerged was the need for controlled access to certain *Milk Matters* information. Some information, such as depot locations, is considered sensitive, and is only revealed to active donors. The concern is that if this information was public, it might result in people not registered with *Milk Matters* dropping off donations, which ultimately cannot be used by them as they come from an unknown source. Thus, it is important that this information is only accessible by registered donors and staff members, both in terms of what's displayed in the applications and how it is stored in the database.

When presented with our first implementation of this security during the Stage 2 evaluations, many of the donors were initially confused and frustrated by it. However, when they were informed as to the reasoning behind its inclusion, they changed their tune, becoming largely accepting of it.

6.6 Non-Functional Backend Requirements

Among the donors interviewed and surveyed *iPhones* were overwhelmingly the most-owned device, with the remainder owning *Android* devices. Some long-time donors stated that this was the barrier that prevented them from using the previous application, as it only supported *Android* devices. To prevent this scenario from playing out again, it was decided that the donor-facing application would target both the *iOS* and *Android* operating systems.

Staff members, on the other hand, performed almost all their administrative work using computers running *Windows 10*. While mobile phones were occasionally used for communication with donors, both staff members agreed that they would prefer for the staff-facing application to target *Windows 10*.

Additionally, according to the survey results, most donors had access to a relatively high mobile-data cap with 85.7% of participants claimed to have unlimited data available to them, while the remainder reported between 10 and 50 GB a month. This implies that bandwidth management is not a major concern on the donor side.

When asked about whether *Milk Matters* would be able to afford a subscription fee associated with hosting, the CEO of the organization advised us that they could, assuming the sum was relatively small. When presented with an anticipated cost, they claimed they would be able to meet it. However, they would prefer for the solution to remain as cheap as possible, as the organization currently has very few funds to divert to such a cost.

7 FEEDBACK ON FINAL DESIGN

The donor app as tested was found to be, for the most part, easily usable. However, several consistent issues did emerge. For one, most participants were confused by the naming of the "Education" page and did not think to look under it for the educational articles. Unfortunately, connectivity issues were prevalent throughout the meetings once again. While these largely affected the video quality of the interviews, the application at one point ceased to function due to being unable to connect to its authentication services. We also had a more difficult time scheduling these interviews than in the previous stages, with interviews having to be delayed by a week due to every donor finding themselves incredibly busy. Interruptions during the interviews were also higher, usually stemming from the donor's children.

All donor participants claimed to enjoy the donation tracking functionality the most. Particular praise was given to the donation history graphs, with one mother stating: "I've donated so much, but [before this] I had no visual representation of it.". Many donors stated that they usually emailed *Milk Matters* when they made their drop-offs, and that the donation drop-off declarer would streamline this process. However, at least one donor stated that she still expected communication from *Milk Matters* when they did pick up her donations. When asked what functionality they could see themselves using the most, every participant included the donation tracker in their answer.

All donors stated that they found the chosen colour scheme pleasing, as it was incredibly similar to the one used by *Milk Matters* in their other endeavors. The general opinion was that the overall design of the application was straightforward and easy to use, although all donors admitted that they were able to navigate the application easily due to their experiences with the prototype.

During the stage 3 interviews with the *Milk Matters* staff members, both interviewees were able to complete all tasks

without much assistance. However, there were a couple issues that hindered the evaluation. For one, a new bug was discovered by one of the interviewees while editing an article. This bug resulted in her losing her edits to the article and having to start again. In addition, certain instructions within the application were unclear: when asked to copy and paste a depot's address from *Google Maps*, one of the participants understood this as asking for the associated URL, not the physical address as intended. An incident also occurred where the *Jitsi* logo obscured some of the application's buttons from a participant, preventing them from completing one of their assigned tasks.

Both staff members stated that being able to view the donation totals at each depot was their favorite part of the application. If the donor-application were adopted by most of the active donor population, these estimates could be largely relied on as indicators for when pickups should be performed. However, they inquire as to whether it would be possible for them to manually add donations to depots using the staff-facing application. This functionality did not exist, but a work-around was developed to support this (namely, having a staff member declare a drop-off using the donor app with a dummy account). The ability to easily change depot details was described as "Fantastic", as it allows this information to be quickly and reliably transmitted to all donors with minimal effort from the staff. In summarizing her thoughts on this collection of functions, one of the participants stated that "It's all so user friendly and I think it's going to be very useful." Much like the donors, both staff members enjoyed the colour scheme used by the staff-facing application, once again owing to its similarity to the one *Milk Matters* has used in the past. Both staff members felt that, while the application would require training to be used by other staff members, it would probably be extremely simple and once-off in nature. They also commented that their experiences in this study had already sufficiently trained them to use it in the future.

8 DISCUSSION

8.1 Backend Design and Motivation

8.1.1 Platform Choice

Through our stage 1 interviews with *Milk Matters* staff members, it quickly became apparent that the backed implementation would need to be as cheap as possible, as well allow for the secure storage of sensitive information. In order to broadly meet these needs, we decided to investigate several cloud-based solutions, as opposed to a system physically owned by *Milk Matters*. Cloud based services have drastically fallen in cost over the years, and represent a solution that requires no investment in physical infrastructure. Additionally, server up-time is virtually completely consistent, as most established cloud services have multiple solutions in place preventing this from occurring. This is especially notable in South Africa, as any solution based locally would be subject to "loadshedding" (regular, scheduled blackouts). Without the additional investment of a generator, this would result in regular downtimes for any physical servers. Finally, most cloud-based service providers are relatively secure, with attacks on them usually made possible by the client's implementation of the service, and not any inherent weakness in the service itself.

We ultimately settled on *Google Firebase*[5] for several reasons. Most important was the cost associated with it: while many cloud providers provide free tiers of use, *Firebase* supports not only a particularly generous one, but also implements a pay-as-you-go scheme, whereby one only has to pay for the functionality they use. This results in an incredibly low cost-to-client, even in the event of them breaking out of the free tier.

While *Firebase* offers many different services, we opted to use only three in total: the "Realtime Database", the "Firebase Authentication Service", and the "Firebase Hosting". The "Realtime Database" is a NoSQL cloud database that syncs its data across all its clients in real time. Due to this, every client that has managed to sync at least once will keep a local copy of the database, allowing for functionality to be maintained even when the connection to the cloud services is lost. This functionality is especially important in a South African context, where internet connectivity is by no means a constant. "Firebase Authentication" is a prebuilt authentication system, allowing for the easy management of user accounts. Finally, "Firebase Hosting" allows for the easy and free hosting of webapps, something that we leveraged for the staff-facing application.

For the "Realtime Database" under the free pricing tier, we were allocated 1GB of storage, 100 simultaneous connections, and 10GB of downloads per month. While this may seem small, for our purposes it was plenty as most of the data to be stored is be text-only, with most of it being cleared intermittently. Additionally, *Milk Matters* only keeps around 20 active donors at a time, something recorded by Wardle et al. and confirmed to still be true by us [21]. This group would represent the most active users of the application, as they would be the ones using the more query-intensive functionality such as the depot locator and the drop-off declarer. This small size makes it unlikely for 100 simultaneous connections to ever be exceeded.

8.1.2 Database Security

To secure the database, "Realtime Database" comes with an access control system in the form of a "rules" document. This is a JSON document that allows one to set conditions for a database's read and write functions. These conditions default to not allowing either, so permissions must be explicitly declared for an action to occur. Additionally, these rules allow one to enforce a structure to the otherwise structureless NoSQL database. The structure settled on can be seen in Appendix B. When designing these rules, the most important factor was to secure the depot locations from non-donors. It was decided that each user account would be associated with one of three security clearances: non-registered donor, registered donor, and staff. Non-registered donors would be allowed to read articles and news events but would not be allowed

[5] https://firebase.google.com/

to access the depot locator or the drop-off-declarer. Registered donors would be mostly-identical non-donors, but would be allowed to access these sections, as well as write entries into the "suggested articles" table. Finally, Staff would hold all the permissions associated with the donor class but would also be able to write to the news and events table, the educational articles table, and the depot table. Rules were put in place to ensure this and were rigorously tested using the provided "Rules Playground" tool (See Appendix E).

While these security classifications would need to be enforced, they could not be implemented using the "Firebase Authentication" system as is. This system only supports the use of a few pre-determined fields, requiring any additional information to be stored in the "Realtime Database". Additionally, as noted in the staff interviews, a security check would still be required before accessing any of the sensitive data, such as depot locations. We decided to use the donor's associated 'donor number" as the password in this instance, as it would already be known to the donor. *Milk Matters* can, at any time, associate a donor number with an email address using the staff-facing application. If an account registered using that same email attempts to access restricted data, they are recognized as a donor by way of this donor number existing in the database. The rules for this table have been written to only allow users to view fields that match their account's email address. This system was used to allow for the case of a donor account not existing when *Milk Matters* registers the donor number. To check for the Staff security clearance, all staff account IDs are stored under a table named "Staff". If an account's ID is found under this table, it is considered a Staff account. In this case, the database access rules have been written such that a user can only ever view and access a field in this table that corresponds with their account ID.

8.2 Backend-Reliant Functionality Motivation

The Depot Locator was included mainly due to its presence in Wardle et al.'s application, as we aimed to bring over every feature available in that application in some form. However, the functionality allowing it to be updated by staff members was included based on staff comments made during Stage 1 of the interviews, in which they expressed the desire to easily communicate depot changes to donors.

Like the Depot Locator, the Donation Tracker had appeared in the application's previous iteration. The demand for donation tracking was still widespread, as evidenced by the number of donors who claimed interest in the concept. To avoid making the process tedious, and thereby potentially influencing donors to abandon it, we kept the number of fields to fill in per donation at a minimum.

Multiple donors had mentioned that they often contacted *Milk Matters* directly after leaving milk at a depot to inform them of it. *Milk Matters* staff, on the other hand, often lamented that a large chunk of their work was devoted to phoning individual milk banks to determine whether they had anything to be picked up. In response this, we implemented the Donation Dropoff Declarer. By allowing users to easily notify Milk Matters of their donations and collecting all these communications under one centralized page for staff viewing, we were able to sate both demands at once. Additionally, in this way we consolidate all communications of this nature to one platform, easing staff concerns about complexity brought about by maintaining multiple communication channels.

The Educational Articles and News Feed existed in the previous application, and so were brought through. The ability for staff to update the contents of these sections was implemented to prevent said content from going out of date, as well as to allow for the existence of the Suggest an Article functionality.

Social media integration was implemented into the donor-facing app. While a live *Facebook* feed was initially planned for, due to the platform's popularity among the interviewed donors, this was ultimately decided against by *Milk Matters*, as they were concerned that by implementing the feed in the application, donors would be less likely to actually interact with the page by providing comments and the like (as this would be impossible with the proposed implementation). The current implementation allows users to share articles to multiple social media platforms, most importantly including *Facebook* and *Instagram* (as these were the most popular platforms among participating donors).

The "Suggest an Article" function was added to encourage more donor participation with *Milk Matters*. Many donors, both during Wardle's previous study and during ours, expressed the desire for more communication outlets to be present within the application [22]. However, it proved unfeasible to offer true donor-to-donor communication, as this brought with it concerns over the sharing of sensitive data (such as milk donation amounts), and the implicit approval *Milk Matters* would be seen to have towards this content by virtue of hosting it. This approach would also require a large amount of moderation to be performed by *Milk Matters*, something the staff would have trouble with by virtue of their small size. The "Suggest an Article" functionality was formulated to allow for a small, manageable degree of donor-to-organization communication to take place. This approach would not only lessen the work required by *Milk Matters* (as it essentially crowdsources the updating of the Educational Articles), it also requires incredibly little moderation. During the Stage 2 and Stage 3 interviews, many donors were impressed by this functionality, and remarked how it would be a great motivator to continue using the application.

8.3 Remote Co-Design

Conducting co-design during the pandemic has been challenging in its own, unique way. Being forced to rely on videoconferencing for most of our interactions resulted in many interviews being afflicted with issues unique to that medium. Multiple interviews were delayed or interrupted due to technical difficulties, such as interrupted internet connections or device compatibility issues with *Jitsi Meet* itself. Additionally, troubleshooting these issues often became near impossible for the researchers, as their line of

communication to the participant is usually compromised. These infrastructure problems present a real obstacle to conducting co-design remotely, especially in areas where a steady internet connection cannot be guaranteed.

However, the use of videoconferencing did allow for the easy recording and sharing of these interviews within the research team. This meant that, if the researcher transcribing an interview encountered connectivity issues, they were able to consult the video recording after the fact to complete their transcription. It also allowed for the transcribers to check their transcription against the video after the interview, to confirm that they had an accurate summary of the proceedings. Additionally, these recordings also allowed researchers not present during any of the initial interviews to experience them after the fact, allowing every researcher to compare the context of the actual interview to the transcription during the tagging and coding process.

On a positive note, however, the switch to online interviews resulted in an easier scheduling of meetings. In Wardle et al.'s work, they had trouble trying to schedule interviews with mothers, as the time commitment required from the participants made finding time to do so incredibly difficult [21]. However, in the environment of the current pandemic, both the researchers and the donor participants often found themselves working from home. This, combined with the relative ease of hosting and joining an online meeting, made meetings much quicker to take part in, as the mother would not have to waste time travelling to a physical destination to take part in the study. This also made it possible to schedule meetings relatively early or late in the day, increasing the possible hours available to the researchers.

Additionally, the perceived abstract nature of video meetings may have helped the mothers to feel comfortable during the interviews. Every single member of the research team identified as a male, and by extension had relatively little experience and knowledge of the finer points of maternity going into this project. While we made an effort to research these topics before the interviews as best we could, it was feared that the perceived ignorance of this field associated with our demographic would discourage donor participants from discussing maternity-related issues with us. However, since the one-on-one interviews were done through videoconferencing, the impersonal and abstract nature of the medium seemed to render the interactions with the interviewer more impersonal than if they were done in person. In this case, this seemed to distract from the interviewers' demographic, and in turn allow for the donors to feel more comfortable discussing matters related to maternity.

7 CONCLUSIONS AND FUTURE WORK

Several pieces of functionality were suggested by the participants but were ultimately not included in the final application due to development time constraints. For instance, during the Stage 3 interviews both staff members suggested the ability to manually add milk donations to the "Dropoff Declarer" using the staff application. This would allow them to account for any donors that have not used to application to declare a drop-off but have instead contacted *Milk Matters* in some other fashion. While there currently exists a work-around to support this, a more standardized method of performing this action could allow for much more accurate tracking of drop-off amounts.

While the co-design process was forced to be completed remotely, several aspects of this approach could be improved in the future. For instance, while the researchers relied on having the participants navigate both the prototype and the final application verbally, this was less than ideal as it was not an accurate representation of using the applications. In future efforts, researchers could attempt to give control of their screens to participants using some form of "Remote Access" software, allowing participants to navigate the prototypes themselves. Additionally, beta-testing programs such as *Apple's TestFlight* could be utilized in longer-form studies to give participants early access to the application on their mobile phones, without having to meet physically. Finally, while it was not explored in this context for several reasons, future work could attempt to simulate in-person workshops using multi-participant videoconferences.

Ultimately, however, the remote co-design process was largely a success: by and large, the basic tenets of co-design (that is, collaboration between the designer and the target users) was both enabled by the use of videoconferencing, and acted on by the researchers. Most issues encountered during this co-design process, such as the late participation of donor mothers, did not result from the digital medium on which it was conducted, but instead from the inexperience of the researchers in planning and executing such a project. In the context of this project, in fact, the remote nature of the interactions helped the donor participants to discuss breast milk donation more openly with an entirely male research team.

Both final applications have been enhanced with additional functionality made possible by the implementation of a client-server architecture. Features, such as the "Drop-off Declarer" and the "Suggest an Article" work to both motivate donors to take a more active role in the *Milk Matters* community, as well as help lessen the workload of said organization's staff members. The backend system itself was designed around the constraints inherent to *Milk Matters* as a non-profit organization, and represents a robust, low-cost method of implementing a client-server architecture within an application. Additionally, the implementation of differing levels of security clearance along with periodic security checks allows for sensitive data to only be accessible by users cleared by *Milk Matters*, while still allowing any interested member of the public to use the rest of the application's functionality. Based on feedback from the stage 3 walkthroughs, both donors and staff members are incredibly happy with the functionality implemented and are excited for the applications launch. Ultimately, the developed applications seem to meet many of the needs laid out by both donors and staff members and should aid *Milk Matters* for years to come.

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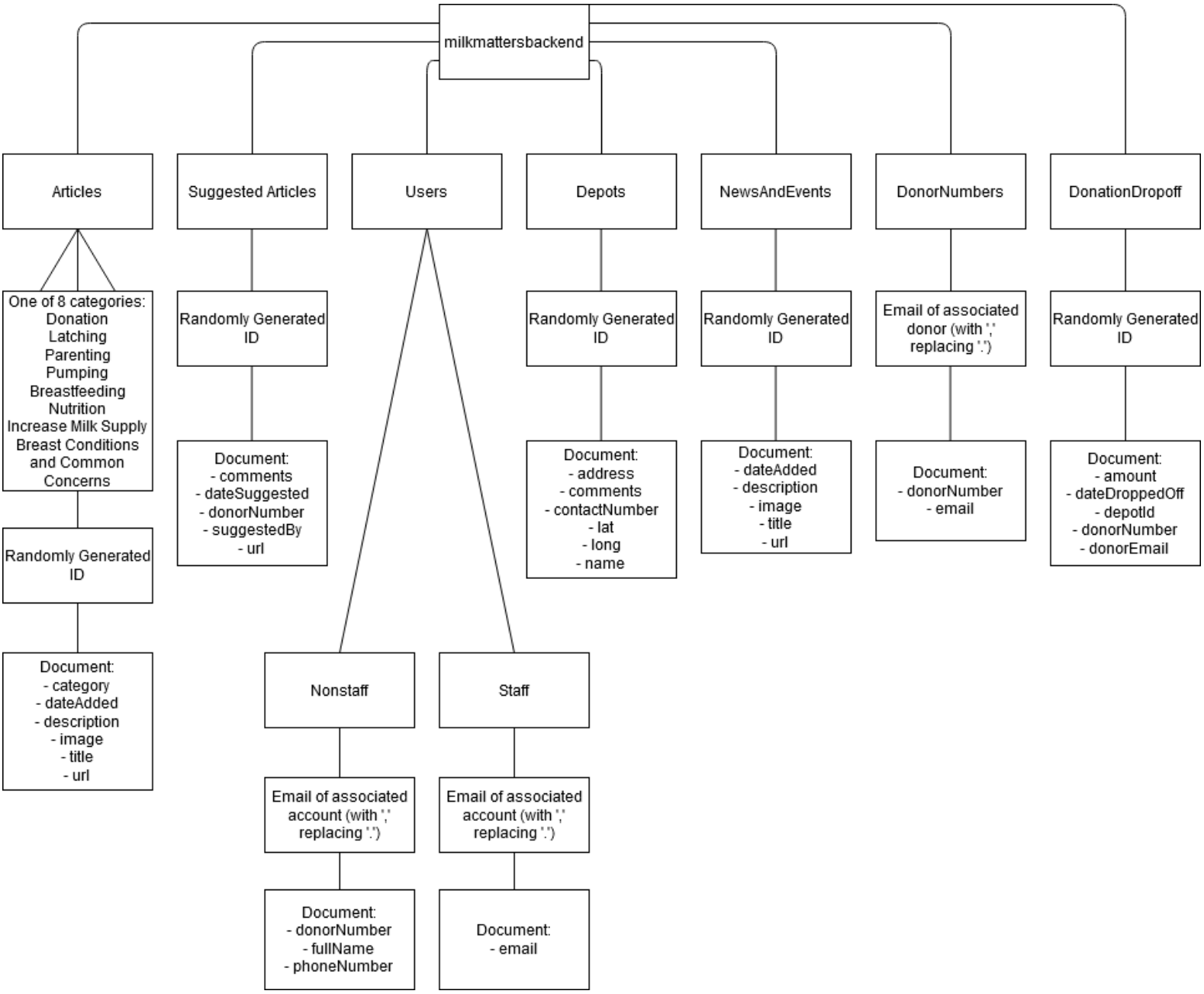
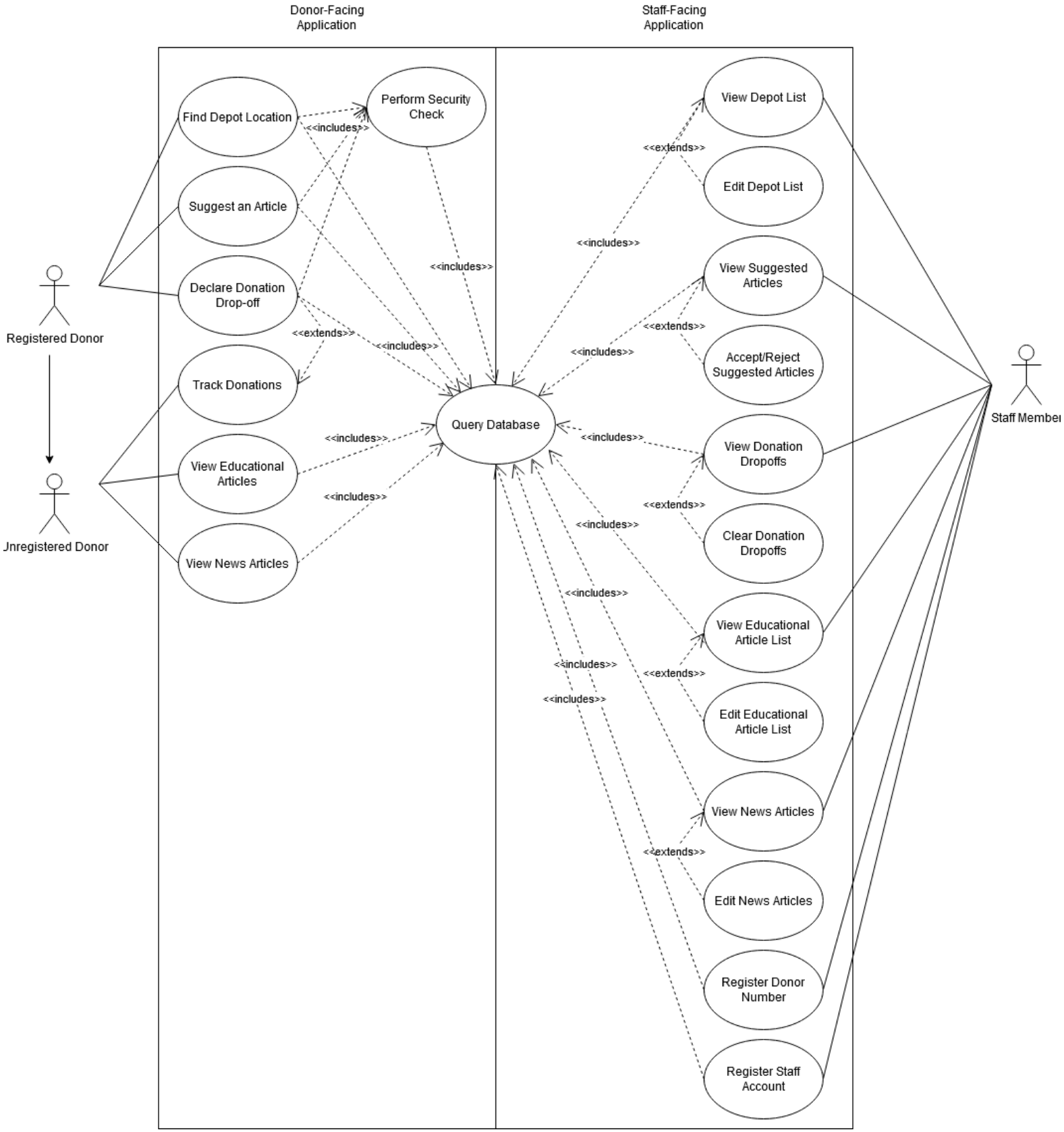
Appendix A: Division of Work

Researcher	Responsibilities
Pieter Gerhard Serton	• Design and implementation of all cloud-based services. • Testing of cloud-based database security. • Assisting in the design of prototypes for both the donor-facing application and the staff-facing application. • Assisting in the design and development of both the donor-facing application and the staff-facing application. • Conducting interviews with donors and staff members.
Dino Bossi	• Design and development of donor-facing application. • Testing of donor-facing application. • Assisting in the design of prototypes for both the donor-facing application and the staff-facing application. • Conducting interviews with donors and staff members.
Gustavo Amicis M. de Souza Mendes	• Design and development of staff-facing application. • Testing of staff-facing application. • Assisting in the design of prototypes for both the donor-facing application and the staff-facing application. • Conducting interviews with donors and staff members.

Appendix B: Database Design Diagram



Appendix C: Use-Case Diagram



Appendix D: Application Documentation

Documentation for this project is hosted online via GitHub, and can be accessed through the following links:
Donor-Facing Application: https://gerhardserton.github.io/Milk_Matters_Donor_Facing_App/
Staff-Facing Application: https://gerhardserton.github.io/Milk_Matters_Staff_Facing_App_Documentation/

Appendix E: Testing Document

Introduction

This document details the testing methodology used to verify the security of the *Milk Matters'* Application Database. This database was implemented as a "Realtime Database", using *Google's Firebase* platform. Testing was accomplished using the built-in "Rules Playground" feature, which allows one to simulate reads, writes, and sets to the database while associated with various authentication tokens. The tool then informs the user whether the operation would have succeeded or failed. Using this tool, we simulated four different levels of authentication: no authentication present, authenticated as a non-registered donor, authenticated as a registered donor, and authenticated as a staff member. Depending on the area of the database to be accessed, these different security clearances would be permitted to perform different actions. The aim of this testing was to ensure that each account type could only perform operations intended for it to perform.

Test Cases

Test ID	1
Purpose	To ensure that all 4 security levels can only perform the actions expected of them when querying the "Depots" section of the database.
Tasks	1. Attempt to read a depot from the "Depots" section of the database without an authentication token. 2. Attempt to write to the "Depots" section of the database without an authentication token. 3. Attempt to read a depot from the "Depots" section of the database with an authentication token associated with a non-registered donor account. 4. Attempt to write to the "Depots" section of the database with an authentication token associated with a non-registered donor account. 5. Attempt to read a depot from the "Depots" section of the database with an authentication token associated with a registered donor account. 6. Attempt to write to the "Depots" section of the database with an authentication token associated with a registered donor account. 7. Attempt to read a depot from the "Depots" section of the database with an authentication token associated with a staff account. 8. Attempt to write to the "Depots" section of the database with an authentication token associated with a staff account.
Expected Outcome	Tasks 1, 2, 3, 4, and 6 are expected to fail. Tasks 5, 7, and 8 are expected to succeed.
Actual Outcome	Tasks 1, 2, 3, 4, and 6 failed. Tasks 5, 7, and 8 succeeded.

Test ID	2
Purpose	To ensure that all 4 security levels can only perform the actions expected of them when querying the "Articles" section of the database.
Tasks	1. Attempt to read an article from the "Articles" section of the database without an authentication token. 2. Attempt to write to the "Articles" section of the database without an authentication token. 3. Attempt to read an article from the "Articles" section of the database with an authentication token associated with a non-registered donor account. 4. Attempt to write to the "Articles" section of the database with an authentication token associated with a non-registered donor account. 5. Attempt to read an article from the "Articles" section of the database with an authentication token associated with a registered donor account. 6. Attempt to write to the "Articles" section of the database with an authentication token associated with a

	registered donor account. 7. Attempt to read an article from the "Articles" section of the database with an authentication token associated with a staff account. 8. Attempt to write to the "Articles" section of the database with an authentication token associated with a staff account.
Expected Outcome	Tasks 1, 2, 4, and 6 are expected to fail. Tasks 3, 5, 7, and 8 are expected to succeed.
Actual Outcome	Tasks 1, 2, 4, and 6 failed. Tasks 3, 5, 7, and 8 succeeded.

Test ID	3.1
Purpose	To ensure that all 4 security levels can only perform the actions expected of them when querying the "DonorNumbers" section of the database.
Tasks	1. Attempt to read a donor number from the "DonorNumbers" section of the database without an authentication token. 2. Attempt to write to the "DonorNumbers" section of the database without an authentication token. 3. Attempt to read a donor number from the "DonorNumbers" section of the database with an authentication token associated with a non-registered donor account. 4. Attempt to write to the "DonorNumbers" section of the database with an authentication token associated with a non-registered donor account. 5. Attempt to read a donor number from the "DonorNumbers" section of the database with an authentication token associated with a registered donor account. 6. Attempt to write to the "DonorNumbers" section of the database with an authentication token associated with a registered donor account. 7. Attempt to read a donor number from the "DonorNumbers" section of the database with an authentication token associated with a staff account. 8. Attempt to write to the "DonorNumbers" section of the database with an authentication token associated with a staff account.
Expected Outcome	Tasks 1, 2, 3, 4, 6, and 7 are expected to fail. Tasks 5 and 8 are expected to succeed.
Actual Outcome	Tasks 1, 2, 3, 4, 6, and 7 failed. Tasks 5 and 8 succeeded.

Test ID	3.2
Purpose	To ensure that registered donor accounts can only read their own donor numbers in the "DonorNumbers" section of the database
Tasks	1. Attempt to read a donor number that is not stored under the account's email address from the "DonorNumbers" section of the database using a registered donor account.

Expected Outcome	Task 1 is expected to fail.
Actual Outcome	Task 1 failed.

Test ID	4
Purpose	To ensure that all 4 security levels can only perform the actions expected of them when querying the "NewsAndEvents" section of the database.
Tasks	1. Attempt to read a news item from the "NewsAndEvents" section of the database without an authentication token. 2. Attempt to write to the "NewsAndEvents" section of the database without an authentication token. 3. Attempt to read a news item from the "NewsAndEvents" section of the database with an authentication token associated with a non-registered donor account. 4. Attempt to write to the "NewsAndEvents" section of the database with an authentication token associated with a non-registered donor account. 5. Attempt to read a news item from the "NewsAndEvents" section of the database with an authentication token associated with a registered donor account. 6. Attempt to write to the "NewsAndEvents" section of the database with an authentication token associated with a registered donor account. 7. Attempt to read a news item from the "NewsAndEvents" section of the database with an authentication token associated with a staff account. 8. Attempt to write to the "NewsAndEvents" section of the database with an authentication token associated with a staff account.
Expected Outcome	Tasks 1, 2, 4, and 6 are expected to fail. Tasks 3, 5, 7, and 8 are expected to succeed.
Actual Outcome	Tasks 1, 2, 4, and 6 failed. Tasks 3, 5, 7, and 8 succeeded.

Test ID	5
Purpose	To ensure that all 4 security levels can only perform the actions expected of them when querying the "SuggestedArticles" section of the database.
Tasks	1. Attempt to read an item from the "SuggestedArticles" section of the database without an authentication token. 2. Attempt to write to the "SuggestedArticles" section of the database without an authentication token. 3. Attempt to read an item from the "SuggestedArticles" section of the database with an authentication token associated with a non-registered donor account. 4. Attempt to write to the "SuggestedArticles" section of the database with an authentication token associated with a non-registered donor account. 5. Attempt to read an item from the "SuggestedArticles" section of the database with an authentication token associated with a registered donor account. 6. Attempt to write to the "SuggestedArticles" section of the database with an authentication token associated with a registered donor account. 7. Attempt to read an item from the "SuggestedArticles" section of the database with an authentication

	token associated with a staff account. 8. Attempt to write to the "SuggestedArticles" section of the database with an authentication token associated with a staff account.
Expected Outcome	Tasks 1, 2, 3, 4, and 5 are expected to fail. Tasks 6, 7, and 8 are expected to succeed.
Actual Outcome	Tasks 1, 2, 3, 4, and 5 failed. Tasks 6, 7, and 8 succeeded.

Test ID	6.1.1
Purpose	To ensure that all 4 security levels can only perform the actions expected of them when querying the "Users/Nonstaff" section of the database.
Tasks	1. Attempt to read an item from the "Users/Nonstaff" section of the database without an authentication token. 2. Attempt to write to the "Users/Nonstaff" section of the database without an authentication token. 3. Attempt to read an item associated with the account's email from the "Users/Nonstaff" section of the database with an authentication token associated with a non-registered donor account. 4. Attempt to write to an item associated with the account's email on the "Users/Nonstaff" section of the database with an authentication token associated with a non-registered donor account. 5. Attempt to read an item an item associated with the account's email from the "Users/Nonstaff" section of the database with an authentication token associated with a registered donor account. 6. Attempt to write to an item associated with the account's email on the "Users/Nonstaff" section of the database with an authentication token associated with a registered donor account. 7. Attempt to read an item from the "Users/Nonstaff" section of the database with an authentication token associated with a staff account. 8. Attempt to write to the "Users/Nonstaff" section of the database with an authentication token associated with a staff account.
Expected Outcome	Tasks 1 and 2 are expected to fail. Tasks 3, 4, 5, 6, 7, and 8 are expected to succeed.
Actual Outcome	Tasks 1 and 2 failed. Tasks 3, 4, 5, 6, 7, and 8 succeeded.

Test ID	6.1.2
Purpose	To ensure that registered and non-registered donor accounts can only read their own donor numbersaccount details in the "Users/Nonstaff" section of the database
Tasks	1. Attempt to read an item that is not stored under the account's email address from the "Users/Nonstaff" section of the database using a non-registered donor account. 2. Attempt to read an item that is not stored under the account's email address from the "Users/Nonstaff" section of the database using a registered donor account.

Expected Outcome	Tasks 1 and 2 are expected to fail.
Actual Outcome	Tasks 1 and 2 failed.

Test ID	6.2.1
Purpose	To ensure that all 4 security levels can only perform the actions expected of them when querying the "Users/Staff" section of the database.
Tasks	1. Attempt to read an item from the "Users/Staff" section of the database without an authentication token. 2. Attempt to write to the "Users/Staff" section of the database without an authentication token. 3. Attempt to read an item associated with the account's email from the "Users/Staff" section of the database with an authentication token associated with a non-registered donor account. 4. Attempt to write to an item associated with the account's email on the "Users/Staff" section of the database with an authentication token associated with a non-registered donor account. 5. Attempt to read an item an item associated with the account's email from the "Users/Staff" section of the database with an authentication token associated with a registered donor account. 6. Attempt to write to an item associated with the account's email on the "Users/Staff" section of the database with an authentication token associated with a registered donor account. 7. Attempt to read an item from the "Users/Staff" section of the database with an authentication token associated with a staff account. 8. Attempt to write to the "Users/Staff" section of the database with an authentication token associated with a staff account.
Expected Outcome	Tasks 1 , 2, 3, 4, 5, and 26 are expected to fail. Tasks 3, 4, 5, 6, 7, and 8 are expected to succeed.
Actual Outcome	Tasks 1 , 2, 3, 4, 5, and 26 failed. Tasks 3, 4, 5, 6, 7, and 8 succeeded.

Test ID	6.2.2
Purpose	To ensure that staff accounts can only read their own account details in the "Users/Nonstaff" section of the database
Tasks	1. Attempt to read an item that is not stored under the account's email address from the "Users/Nonstaff" section of the database using a staff donor account.
Expected Outcome	Task 1 is expected to fail.

Actual Outcome	Task 1 failed.

Test ID	7
Purpose	To ensure that all 4 security levels can only perform the actions expected of them when querying the "DonationDropoffs" section of the database.
Tasks	1. Attempt to read an item from the "DonationDropoffs" section of the database without an authentication token. 2. Attempt to write to the "DonationDropoffs" section of the database without an authentication token. 3. Attempt to read an item associated with the account's email from the "DonationDropoffs" section of the database with an authentication token associated with a non-registered donor account. 4. Attempt to write to an item associated with the account's email on the "DonationDropoffs" section of the database with an authentication token associated with a non-registered donor account. 5. Attempt to read an item an item associated with the account's email from the "DonationDropoffs" section of the database with an authentication token associated with a registered donor account. 6. Attempt to write to an item associated with the account's email on the "DonationDropoffs" section of the database with an authentication token associated with a registered donor account. 7. Attempt to read an item from the "DonationDropoffs" section of the database with an authentication token associated with a staff account. 8. Attempt to write to the "DonationDropoffs" section of the database with an authentication token associated with a staff account.
Expected Outcome	Tasks 1, 2, 3, 4, and 5 are expected to fail. Tasks 6, 7, and 8 are expected to succeed.
Actual Outcome	Tasks 1, 2, 3, 4, and 5 failed. Tasks 6, 7, and 8 succeeded.