Refresher Training through Gamified Activities for Frontline Healthcare Workers on Maternal and Newborn care

Submitted in partial fulfillment of the requirements
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Doctor of Philosophy

by

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Dedicated to my beloved parents.

Thesis Approval

This thesis entitled **Refresher Training through Gamified Activities for Front-line Healthcare Workers on Maternal and Newborn care** by **Arka Majhi** is approved for the degree of **Doctor of Philosophy**.

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Declaration

I declare that this written submission represents my ideas in my own words and where others ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission. I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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CERTIFICATE OF COURSE WORK

This is to certify that **Arka Majhi** (Roll No. 184350001) was admitted to the candidacy of Ph.D. degree on 12 July 2019, after successfully completing all the courses required for the Ph.D. programme. The details of the course work done are given below.

S.No	Course Code	Course Name	Credits
1	TD 606	Public Policy and Governance in Technology and Development	6
2	TD 621	Food Processing and Nutrition Delivery	6
3	DE 668	Instructional Design	4
4	TD 694	Seminar	4
5	TD 610	Contemporary Critical Issues in Technology and Development	0
6	HS 791	Communication Skills -I	PP
7	TD 792	Communication Skills -II	PP
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Abstract

High and persistent levels of child malnutrition continue to be a matter of concern in India. The universal coverage of children under different healthcare and nutritional programmes has witnessed a rapid increase in the number of Frontline Workers (FLWs) or Community Healthcare Workers (CHWs) i.e. the Anganwadi Workers (AWWs) and the Accredited Social Health Activists (ASHAs). The job training and the refresher training of these workers leave a lot to be desired. The capacity deficit of field functionaries has been identified as a major factor affecting the effectiveness of this programme. Given the massive numbers of field functionaries and the continuously advancing base of knowledge and techniques, conventional training pedagogy is ineffective in building and updating the capacity of the Frontline Healthcare Workers and their supervisors. With the improvement of technology and widespread availability of smartphones in cities as well as rural and tribal villages of India, access to digital training systems can potentially benefit the healthcare workers and the healthcare system to a large extent, rendering reduced malnutrition and infant mortality rate, countrywide. The conventional training methods are proving to be inadequate for the task. Gamification of the training material for the refresher training and use of digital tools for its dissemination offers one potential solution to this problem which is the subject matter of the doctoral research. The care protocol is gamified through different gaming options, and digital versions of these games are developed which are playable on the android platform. Card games appear as highly suitable for this purpose, and their customization for the training content is in progress. The study compares the effectiveness of the game-based learning pedagogy and conventional classroom instruction with a group of ASHAs, and discusses ways to make it an adequate refresher training substitute.

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List of Abbreviations

ASHA	Accredited Social Health Activist
AWW	Anganwadi Worker
AWH	Anganwadi Helper
AWC	Anganwadi Centre
CHW	Community Health Worker
NFHS	National Family Health Survey
CNNS	Comprehensive National Nutrition Survey
ICDS	Integrated Child Development Services
IFA	Iron and Folic Acid
MWCD	Ministry of Women and Child Development
LMIC	Low and Middle income Countries
LISA	Local Indicators of Spatial Association
PHC	Primary Healthcare Centre
mHealth	Mobile Health
FDG	Focused Group Discussion
MCPC	Mother and Child Protection Card
IAP	Indian Academics of Paediatrician
ORS	Oral Rehydration Solution
ANC	Antenatal Care
GLO	General Learning Objectives
SLO	Specific Learning Objectives

MCQ	Multiple Choice Question
CINI	Child in Need Institute

Chapter 1

Introduction

1.1 Background

Healthcare systems worldwide are struggling with a shortage of Community Health Workers (CHWs) or trained health workers, especially in low-and-middle-income countries (LMICs), reaching an estimated deficit of 80 million by 2030 (Organization, 2016). It remains a challenge for LMICs to train or educate CHWs ensuring the most vulnerable population's good health and well-being (Organization, 2016). National Family Health Survey 5 (NFHS-5) has shown a decline in levels of child malnutrition in India for children under 5 years age. Stunting reduced from 38.4% (NFHS-4 2015-16) to 35.5% (NFHS-5 2019-21). Wasting, which stood at 21% (NFHS-4), has reduced to 19.3% (NFHS-5). The levels of underweight reduced from 35.8% (NFHS-4) to 32.1% (NFHS-5). High and persistent child malnutrition levels with tardy reduction, seen in successive health surveys, continue to be a matter of concern in India. It draws attention to the need to revamp the more than 45-year-old flagship program of the Government of India, the Integrated Child Development Services (ICDS), under the Ministry of Women and Child Development (MWCD), focusing on children (below 6 years), pregnant women, and lac-

tating mothers. Studies strongly flag the need for improved knowledge and awareness among AWWs and ASHAs, whose knowledge and skills impact the program's implementation.

ASHAs are state-government-employed CHWs tasked with delivering last-mile care for their own community. They are not salaried but incentivized for their work which is considered voluntary in nature. The role of ASHAs is to act as an intermediary between their own community and the government healthcare infrastructure. ASHAs' activities include data collection, healthcare provision, and information dissemination in her own community. Special attention is paid to the health of mother and child.

CHW's education level and nutrition knowledge plays an essential role in her regular duties (Gujral et al., 1991). The authors also commented that most of the CHWs were unclear about the basics of their daily work. The unskilled population among AWWs was considered as the leading cause for keeping growth charts unfilled. The rate of success of ICDS largely depends on the way the AWWs are prepared to tackle the problem of malnutrition, which thus becomes a concern, to train and upgrade AWWs with quality training with enhanced and advanced nutrition knowledge as it determines the performance of AWWs (Gujral et al., 1991). Training and supervision were identified as one of the most ignored intervention-related aspects in systematic reviews of CHW success factors (Kok et al., 2015). Research on training and education of Community Healthcare workers is scarce. Few academic researchers have attempted to train and educate Community Healthcare workers using technology solutions like ICT, community radio and multimedia as a medium through feature phones and smartphones (Yadav et al., 2017, 2019a,b). This research builds on and contributes to the previous research studies conducted by Indian researchers on making games and gamified systems (Majhi et al., 2021; Tulaskar, 2020) for training Community Healthcare Workers.

1.2 Motivation

- Traditionally the field workers are trained in a physical classroom environment following the cascading model of teaching the Master Trainer of state and districts and then the field functionaries. In these massive teaching classes, it is often difficult to pay attention to the learners or the field functionaries individually. The trainers and learners also complain

about inadequate infrastructure for conducting training and assessing the knowledge gains in crowded classrooms.

- The rise in smartphone ownership among healthcare workers in India opens up an opportunity to utilize mHealth approaches to bridge the gap of healthcare access and engagement with the beneficiaries of the target population.

1.3 Research objectives

In this doctoral research, the study focuses on understanding if a content gamification approach in refresher training can help educate frontline healthcare workers in India. We would also compare the benefits which the gamified activity provides compared to other strategies and discuss the challenges faced while designing it for community healthcare training. In this research, we would also attempt to answer the following questions.

1. Can a gamified activity approach effectively train healthcare workers in India?
2. Are there benefits of gamified activity approach when compared to other approaches of training in community healthcare?
3. What are the different challenges and considerations to consider while designing gamified activities from scratch intended to train community healthcare workers?

1.4 Method

The process of designing gamified activities and evaluation would be broadly carried out in 6 stages following an iterative design thinking process.

- Definition of the set of objectives
- Literature Review of previous research
- Design of the game (participatory design)

  - Designing the challenges
  - Drafting rules of playing the game
  - Validation of the educational material
  - Evaluation of the physical activity through field testing or play testing
    * Tests for knowledge retention and their application in real life (Kirkpatrick's lower and higher levels)

- Making a digital version of the gamified activity for smartphones and tablets
- Evaluation of the digital gamified activity through field testing (conducting similar tests as performed for the physical activity)
- Iterative redesigning and reevaluating as required
- Compare the results of the physical and the digital gamified activity

Chapter 2

Review of Literature

2.1 Access to mobile phones and internet services

According to a press release (Gupta, 2021), out of the 1173.83 million telephone subscribers as on December 31, 2020 in India, 44.8% (525.92 million) were rural telephone subscribers. Out of them, 99.66% (524.11 million) were rural wireless telephone subscribers making 45.43% share of the total wireless subscribers. Based on NSS 75th Round (July 2017-June 2018) (MoSPI, 2015), it was found that 15% of rural households in India have access to the internet. Finance Minister of India Nirmala Sitharaman, while presenting the Union Budget 2020-21 announced that over 0.6 million AWWs in India were smartphone equipped in 2020 for uploading the nutritional status of more than 100 million households. The rise in smartphone ownership among healthcare workers in India opens up an opportunity to utilize mHealth approaches to bridge the gap between healthcare access and engagement with the beneficiaries of the target population (Ganapathy and Ravindra, 2008; Bassi et al., 2018; Madanian et al., 2019).

2.2 Introductin to mHealth

Mobile Health or mHealth is defined as "medical and public health practice supported by mobile devices" (WHO, 2011), thus having the potential to overcome the limitations of the traditional methods of receiving child and maternal healthcare through job cards or printed paper brochures. mHealth is a means to disseminate healthcare information cost-effectively and personalized to socioeconomic and cultural needs to fit the context.

Researchers from developing countries have provided suggestions for designing effective mHealth interventions (Kumar and Anderson, 2015). These include communicating with the community through radio and text messages (both automatic and human-aided). Studies have been conducted to motivate health workers and increase their knowledge by deploying short videos on mobile phones (Ramachandran et al., 2010). Another study (Kumar and Anderson, 2015) from India found that watching short films on mother and child care empowered Health Workers and mothers to manage pregnancies proactively. Shah. et al. (Shah et al., 2017) from India did a similar study on an incentive-based approach for training AWWs through mobile-based videos. The AWWs' feature phones were loaded with videos related to mother and child healthcare. A few questions with their correct answers related to the content of the video were appended to the video. After watching these videos, AWWs were supposed to call on a toll-free number, where they would be quizzed on the same questions as shown in a particular topic video. AWWs were awarded cellular talk time as an incentive for answering correctly. Another study (Pérez et al., 2020) from India, found that 'Tika Vaani', an IVR-based mHealth solution to improve knowledge on immunization has shown significant results in improving healthcare knowledge if the content is customized to meet the needs of less-literate users.

2.3 mHealth interventions through e-Learning, Serious Games and Gamification

e-Learning is a teaching and learning approach, through an educational model focusing on improving access to training, communication, and interaction by adopting electronic media

and devices for promoting novel understanding and enhancing learning (Sangrà et al., 2012). 'Blended Learning' happens when e-Learning and face-to-face teaching are combined. 'Educational game' pedagogy requires learners' participation while performing competitive activities following previously set game rules. A Cochrane review (Akl et al., 2010) studied two physical games for educating healthcare professionals and confirmed games as an effective strategy for teaching. The application of games focusing on 'serious intent' has been observed in various domains like health, training, defense, education, military, aviation, city planning, politics, and ecology with multiple approaches (Alvarez 2012). Researchers have been using similar terms like Game-Based-Learning, Games-for-Good, Alternative-Purpose-Games, (Sawyer and Smith, 2008), and Edugaming (Angarita et al., 2005) while describing similar interventions.

Clark Abt first outlined the idea of 'Serious Games' in his book, published in 1970 named 'Serious Games'. He described 'Serious Games' as the games that "have an explicit and carefully thought-out educational purpose and are not intended to be played primarily for amusement" (Abt, 1970). Serious Games combines learning theory and empirical outcomes for improving skill learning along with the principles of game design. Interventions through serious game design can enhance cognitive, social, and health-related skills beyond the context of the game (Ritterfeld et al., 2009; Giunti et al., 2015). The number of articles and systematic reviews on serious games in healthcare education is growing (Graafland et al., 2014; de Ribaupierre et al., 2014; Laamarti et al., 2014; De Wit-Zuurendonk and Oei, 2011).

For this doctoral research, the definition by Alvarez 2015 and 2012 would be considered. The games created with the serious purpose of providing healthcare education delivered through digital devices are Serious Games. Serious Games provide a gaming experience through rules, engines, and mechanics. But gamification tries to create a similar experience through applying game mechanics and involving fun while performing mundane activities with developing motivational and cognitive abilities. Sebastian Deterding defined gamification as the "use of game design elements in non-game contexts" (Deterding et al., 2011b,a; Deterding, 2011, 2012). Gamification potentially allows higher involvement of the player in setting up the objectives and outcomes, thus personalizing the intervention and make it cost-effective (Wortley). The increase in inequality of access to resources for healthcare, lack of adherence to treatment (Vicente et al., 2014), and increased healthcare cost (Lenihan, 2012) generated the need for applying gamification in digital healthcare services. Self-Determination Theory suggests use of intrinsic and

extrinsic motivations in the context of game design (Ryan and Deci, 2000). Extrinsic motivators are game elements such as badges, points, progressbar and leaderboards (Ryan and Deci, 2000). While extrinsic motivators are the feelings of 'mastery' or feeling of accomplishment towards the goal, 'autonomy' or the freedom of sense of play, and 'relatedness' or connecting players to goal and passion (Deterding et al., 2011b).

2.4 Educational Theories and Serious Gaming

Malcolm, in his book (Knowles, 1980), stresses the factors which support adult learning. Serious Games and Gamification techniques can also help in achieving those.

- With every experience faced, there is a tendency to move from dependency to autonomy. Games facilitate this by providing an active learning environment through independence in moves or choices made in games.
- Past learning is used in dealing with our current problems. Games challenge us to deal with different situations as per our prior knowledge.
- With age, people tend to be more focused on the task goal. Games train us to be goal-oriented by targeting small tasks and completing levels.
- With age people tends to learn from tasks, based on practical problems and less on educational content. Games facilitate learning through design problems, which are inspired by practical problems.

Learning through games supports the 'cognitive theory of multimedia learning' (Mayer, 1997), which says that learning happens better when both visual and auditory senses are involved. Another theory (Siemens, 2005) proposes that learning is not a linear process, but meandering through changing environment. Serious Games also follow similar mechanisms. Researchers (Mey, 2005; Gee, 2012) showed that games are compelling as learning happens within meaningful contexts. Any training method can be evaluated for effectiveness and validated through Kirkpatrick's 4 levels of outcome (McFarlane, 2006), training reaction (1^{st} Level), improvement in learning (2^{nd} Level), improvement in behaviour (3^{rd} Level) and training outcome or results (4^{th} Level). Training through Serious Games has resulted in longer engagement

in training and improvements in learning gains. Experiential Learning Theory (Kolb, 1984) suggests that after gaining knowledge, every learner observes, reflects, and analyzes it, creating abstract concepts in mind and actively experimenting with them by applying their learnings to see the results. Serious Games can target every stage of this process and support the creation of knowledge through the experience of game play. For combining learning and gaming, Ritterfeld suggests three ways (Ritterfeld and Weber, 2006).

- Reinforcement model: Learning rewarded with entertainment
- Motivation model: Entertainment encourages learner's interest and attention
- Blended model: Process and result of learning itself becomes exciting

Out of them the blended approach seems to be most effective because it provides intrinsic satisfaction of learning (Breuer and Bente, 2010), and provide fun while learning (Koster, 2010).

To achieve predefined learning objectives in mind, a Serious Game in its design phase needs to follow a grounded design approach (Hannafin et al., 1997) and align with educational theories. Choosing behaviorism or constructivism as an approach while designing the game can influence the learning theories and instructional strategies of the playful activity (Gunter et al., 2008). The learning approach defines the characteristics of the training environment. It also controls the pace and frequency of interactions intended for critical learning through the Serious Game targeted toward the learning outcomes of the learner.

In this research, the constructivist theory of learning for designing was chosen. The health-care workers would need to understand information and extract meaning from the game's content. Then, they will construct knowledge by applying the learning to overcome the game's situations which would ideally cascade later in their daily practices. For the construction of knowledge, Bloom proposes six levels of understanding of a subject ranging from simple to challenging levels (Krathwohl et al., 1969). Bloom's taxonomy acts like a palette for choosing suitable learning approaches corresponding to the knowledge level expected from the learner.

Gagné's nine-step framework (Gagné et al., 2010) for creating learning environments ensures that the learner will master the content, reach the learning objectives and ascend through Bloom's six levels of learning. Scenarios of Serious Games are created by keeping in mind Bloom's taxonomy and Gagné's instructional events, providing a methodological guide for

developing strategies for learning. The activities of the storyline should be intended toward learning objectives of each level throughout the scenario.

2.5 Current status of child immunization

Through immunization, 2-3 million lives are saved each year from diseases that vaccines could prevent (Andre et al., 2008). Across the world, about 19.4 million children, with age less than 12 months, missed the necessary vaccination, with 11.7 million from LMIC countries and 2.6 million of them being Indian (World Health Organization, 2016). A study on NFHS-4 data found that the immunization cover of children in 163 districts in India was less than half (Panda et al., 2020). 47% of children belonging to the lowest wealth quantile households in India, are not fully immunized, and any health insurance does not cover 71% of families (Indian Institute Population Sciences and Ministry of Health and Family Welfare, 2007). As a result, they end up spending significant amounts on healthcare, pushing almost 32-39 million people annually to dip below the poverty line (van Doorslaer et al., 2006; Garg and Karan, 2009).

A study (Panda et al., 2020) performed LISA and spatial regression model on NFHS-4 data. Through this study, it was found that mothers receiving ante and post-natal care had better chances of having their children fully immunized. It also found a strong association of full immunization of children with women empowerment indicators like mothers' literacy and women being the authority of the family. However, in spite of vaccination camps being conducted free of cost in Government Hospitals and all rural or urban Primary Healthcare Centres (PHCs) in India still, a significant number of children are still not vaccinated. The study also found that it is mostly ignorance and unawareness among family members regarding vaccination that increases the likelihood of undernutrition in children and results in child mortality and morbidity. The study also suggests the necessity of sensitizing the population, which would improve access to community healthcare. Pockets of the population with poor healthcare access require more targeted steps to bridge the immunization gap. mHealth technologies could help in improving health outcomes and decrease health inequalities (Peek, 2017).

2.6 Knowledge Gap of healthcare workers and mothers

Another focused group discussion was conducted with mothers in a rural village in South 24-Paraganas district in West Bengal and found that, due to the knowledge gap of healthcare workers, the mothers and children in the community are usually left unaware of the medical care, healthcare delivery, checkup services, family planning, etc. Studies conducted in other parts of India also show similar results. A study (Mani et al., 2020) found mothers' low awareness of tetanus, immunization, iron, and folic acid (IFA) tablets. More than half of the pregnant women were unaware of availing pregnancy care services at ANC visits like blood pressure and weight measurement and abdomen examination. Knowledge regarding high-risk conditions in pregnancy and danger signs in pregnancy was also low. Few mothers knew about the various components of institutional delivery and maternity benefit schemes. Though the knowledge regarding spacing of births and contraception in the post-natal period was better, the postpartum intrauterine contraceptive device was non-existent. The designed game would try to bridge the knowledge gap of the community healthcare workers in the above-mentioned topics.

Chapter 3

Designing the Refresher Training Activity

3.1 Content for designing Refresher Training Activity

Conducting a Focused Group Discussion (FGD) among a group of AWWs and ASHAs, it was found that most CHWs lacked complete knowledge of the immunization schedule, growth monitoring chart, and other aspects of the Mother and Child Protection card (MCP card). The findings of other researchers from different parts of India were also similar to our (Bag and Datta, 2017). A study found that the issuing of MCP cards to pregnant mothers was strongly associated with partial immunization in children (Kizhatil et al., 2019). The child immunization table from the MCP card was chosen as content for the game. This schedule also follows the Indian Academics of Paediatrician (IAP) guidelines (Kasi et al., 2021). A reference to the immunization schedule is in Table A.1 in the Appendix.

3.2 General and Specific Learning Objectives

Trainers usually or subconsciously have in mind the knowledge, skills, and attitudes they want their learners to achieve through the training course. Learning Objectives are the specifications of the sought outcomes of the training. They break the content into smaller modules with measurable or observable specific desired outcomes. The General Learning Objectives (GLOs) and the Specific Learning Objectives (SLOs) were brainstormed in a closed group and decided on. It was found that the contents mostly correspond to the cognitive domain (new knowledge creation) of learning objectives. Hence affective (developing feelings and emotions) and psychomotor (improving physical and manual abilities) domains are not relevant here. But, supportive layering of learning objectives could strive students to step into these domains.

The GLOs of the game are as follows:

Audience : Community Healthcare Workers

- The learner remembers the factual information like immunization schedule and medical supplementation for mother and child

- The learner becomes more aware of the consequences of their actions

The SLOs of the game are as follows:

Condition : They should be able to make the right decision in the gameplay scenario.

Degree : Depending on the number of right decisions taken (the more, the better)

Behavior :

- Memorize the sequence and dosage of immunizations and supplements required by a child from birth to adolescence.

- Memorize the sequence of medicines, immunizations, and checkups required for a pregnant mother.

3.3 Physical Card Play as a Learning Tool

Initial thoughts of game design were that the information about vaccines is displayed to players through blocks of information. Then the player has to make a decision based on the information and the current scenario. Out of many physical tokens and objects of play, card gameplay was chosen as the game artifact. Possibilities of play through card games were explored. Physical card games are ubiquitous. The primary reasons for this are its cost-effectiveness and handling ease. A deck of cards can be played in numerous different ways just by altering the rules. Different groups of cards can be added to the existing deck to enable new ways of playing with it. Multiplayer card game researchers (Bochennek et al., 2007) have shown significant learning advantages through engagement and collaboration. However, published research papers on using card games for training community healthcare workers were not available.

The core learning objective is that the community health workers memorize the sequence and dosage of immunizations and supplements required by the child and mother. Initially, there were thought of modding the classic physical card games like Rummy, Solitaire, Bridge, Teen Patti, etc. It was easier to think along the lines of combining the rules and mechanics of a popular card game with educational content. But in several instances of design iterations, the associated traditional rules of play restricted the fulfillment of our learning objectives. As a result, cherry-picking rules and mechanics were performed from several popular card games, which would address and fulfill the learning objectives of the ASHAs.

3.4 Designing the cards

The content can be categorized into 4 silos depending on the time of delivering the care to the stakeholders. 4 silos of cards were made each symbolizing an immunization, medicine supplement or a care activity or event. They are categorized as follows: ANC (n=14), Children below 1yr (n=22), Children above 1yr (n=15), and PNC (n=9) combined to form a deck of 60 cards. The deck of card design is displayed through Figures : G.1, G.2, G.3, G.4 and G.5 in the Appendix section.

These playing cards are made of the size of a standard playing card or credit card (5.5 X 8.5 cm), made of card paper (200 GSM), and have printed information and graphics on them.

3.5 Combination of cards

These 60 playing cards can be equally divided between 2, 3, 4, 5, or 6 players creating multi-player team combinations. The most common of them is a 4 player match. Theoretically all the 60 cards could be arranged in a total of 60! ways. But for each of those arrangements, there are many duplicate arrangements in which cards 1 to 15 are the same but in a different order (considering 4 player round). Similarly for cards 16 to 30, and so on. For each group of 15, there are 15! ways to rearrange them and not change the cards in each player's hands. That's why four factors of 15! would be in the denominator. The mathematical expression of the number of permutations possible for each player's hand (considering 4 player round) = 60! / (15! x 15! x 15! x 15!).

3.6 Framing Challenges and Rules

- Before starting the game, the players need to get the deck of 60 cards, shuffle it well and distribute it equally to 4 players, 15 cards each.
- Then at each player's turn, they need to put a card of one silo on to the placeholder of the same silo on the board.
- The cards are numbered in order of the months and year. If there are multiple immunizations/cards in an age group, they are numbered $2^1/_5$, $2^2/_5$, $2^3/_5 \ldots$ and so on. This act as a cue for the players to know how many more cards are left to complete the current sequence so that they don't miss a card and jump to the next month or sequence.
- If a player successfully places a card in the placeholder silo, the player gets 2 more chances or play rounds as a bonus.
- If there is no possibility of cards to be placed or 2 bonus rounds are complete, then the

turn goes to the next/following player.

- After one age group is completed, then the following players, in their turn, can place cards in one age group upper than the upper set or lower than the lower set on the board.

- The rounds of play continue until all cards are exhausted from a player's hand. The first player to exhaust the holding cards wins the round and is awarded the first rank, followed by the next players until all cards are exhausted by all players.

3.7 Limitations of playing with physical cards

Physical cards have limitations as follows:

- The rules of the play need to be followed in order to achieve the intended learning. But players need to constantly monitor the activities in order to catch deviations from the rules. This problem can be solved digitally through rules written in the form of algorithms. Every wrong move would be announced through voice cues.

- In India, there are 22 official languages. Different groups have different number literacy levels. Some are comfortable with the script of Devnagri numbers or regional ones, while some are with English numbers. Making customized decks cater to each group won't be scalable.

- The content or the knowledge to be delivered changes with new findings in medical science, which needs to be implemented over the state or country. This translates to adding new cards or scraping off the distributed cards, printing and resupplying new decks to all ASHAs, which is not a scalable solution.

- Mundane chores of play, like shuffling cards, equally distributing cards between the number of players, and packing them up, take up a lot of time for players to do it manually by hand. These can be done digitally in almost no time. It can also be done in an animated sequence to mimic the physical action sequence of shuffling, distributing, and packing up, which are very satisfying to watch in an interface.

3.8 Designing an app-based interface of the same activity

In the digital app, there are 4 foundations on the top which represent 4 silos. The players click on the desired card to pick it and click on the empty foundation to drop it. If there are multiple cards to that sequence (like $2^1/_5$, $2^2/_5$, $2^3/_5 \ldots$), the cards keep stacking over. As soon as the sequence is complete they collapse into the foundation. It opens up possibility to stack cards over or under, the bigger and smaller cards in sequence respectively. A reference to the app's User Interface is shown in Figure H.1 in the Appendix section.

During previous field studies, it was observed that more than half of the ASHAs had an access to smartphones but did not own it. Usually, their husbands own it and share it with their wives, the ASHA. The resource constraints in some player groups, could be addressed if one smartphone could be used by 4 players, turn by turn. 4 players can sit in a circle. A pass button to skip the turn to next player was introduced. After each player plays her move in her turn and end successfully stacking a card, the next player gets the turn. But if there are no moves possible then, the player can click on the Pass button to pass the turn to the next player. The player after completing her turn, orients the phone by turning it towards the next player for her turn to play. Also, an assistive voice would be played announcing the current player's name, to reduce the confusion of whose turn is currently going on.

Following the same game mechanics, rules, and deck of cards, this Android game app was developed. The gameplay analytics of each player would be saved offline and asynchronously stored in an online database whenever the internet would be available, for further analysis. ASHAs having an active data connection would update the scores instantly. It was observed that a number of ASHAs didn't had an active data pack in their smartphone. For them, there would be asynchronous syncing multiple times within a week, whenever she would come to the state-institution for reporting and would connect her smartphone to the Wi-Fi network of the institution (which is usually available).

Chapter 4

Evaluation

4.1 Evaluation method

Through this research study, it would be interesting to understand knowledge gain, retention, and satisfaction after playing the designed game with the intervention group and compare it with a control group with the traditional mode of the classroom refresher course. The evaluation of the game-play intervention program will follow the Kirk Patrick Model of Evaluation (Kirkpatrick, 1950). This model considers evaluation across four levels

1. Level 1: Reaction,
2. Level 2: Learning,
3. Level 3: Behavior, and
4. Level 4: Impact/Results.

The scope of this research study will be limited to conducting level 1 and level 2 evaluations only, as level 3 and 4 evaluates the prolonged effects of the intervention program.

1. Kirk Patrick Level 1 evaluation (Reaction): CHWs' reaction toward the game, gameplay experience, enjoyment, and satisfaction after playing a few rounds of the game will be recorded through feedback forms. The standard SUS questionnaire for evaluating usability covers most of the Level 1 questions. The responses would provide inputs for further modification of the game.

2. Kirk Patrick Level 2 evaluation (Learning): A pre and post-questionnaire on both intervention and control groups will assess the delta learning by measuring the change in the CHWs' knowledge of child immunization and pregnancy care. For comparing if the delta learning is significantly different in one of the cases, paired 2 sample t-test (considering normal distribution) would be conducted.

   Also, the digital game of sorting of immunization cards can compare with the traditional classroom settings. ANOVA for multiple comparison of means and Tukey test to compare pairwise differences or conduct Dunnett's test to compare each group mean to a control mean can be conducted.

An attempt could be made to check Level 3 or Behavior changes by shadowing the CHWs' in immunization camps and understanding the knowledge and attitude about immunization, pre and post intervention. Qualitative studies like coding of the daily experiences of each personas, might show some changes. Level 4 changes like change in percentage of child immunization in large health surveys conducted pre and post intervention, would have too many co-factors and measure the changes would not be exclusive of the intervention.

Apart from learning gains and knowledge retention tests, usability testing and evaluation of this method of learning could be performed.

1. Usability Testing of the designed game (Jakob Nielsen)

   (a) Learnability : How easy is it for a new player to learn how to interact with the interface of the digital game

   (b) Memorability : If the player comes back after some time to play the same game, how easy is it to regain proficiency or to remember what they have learnt, the first time they played the game

(c) Efficiency : Once players have used the interface or the system, how quickly can they perform different tasks

(d) Accuracy : How often do players make mistakes related to the rules

(e) Satisfaction : How is the experience of playing the game. Are the players having fun, enjoying, feeling skilled, gaining mastery, provided context for social interaction, etc.

4.2 Evaluation of the latest prototype

The latest prototype, the playful activity with a deck of 60 physical cards, was field tested in Burhanpur district in Madhya Pradesh. The digital app version couldn't be tested as it was under development. By the next presentation the digital app would have developed and tested it in the field. Prior notification of conducting these field testing sessions was given to the ASHA coordinator and Health Officers of Burhanpur District, Madhya Pradesh.

4.2.1 Participants

ASHAs were recruited in this research through snowball sampling (Goodman, 1961). The demographics of the participants are tabulated in Table: C.1. Participation in the playtesting activity was voluntary, with an option to quit anytime during the research. ASHAs were tried to be compensated for the valuable time and expertise they brought in. Their contribution to our research was immeasurable materialistically. As a token of gratitude, tea, snacks, and sweets were served.

4.2.2 Instrumentation

The instrument used in this study had three sections. All participants expressed their consent to this research by reading the first section of the questionnaire and signing it before every

survey/test. The second section was the demographic data sheet to identify potential group variances. The demographic data sheet consisted of a checklist and gap-fill questions such as age, highest educational grade/degree, and years of experience as an ASHA. The third section was 40 Multiple Choice Questions (MCQ) on all 4 silos, Children below 1 year, above 1 year, ANC and PNC. Questions related to infants and children were on immunization and medicine supplements. This test evaluates the participants' knowledge at the baseline, knowledge gained through intervention, and knowledge retention after a week of practicing the playful activity. A reference to the 3-page questionnaire is in the Appendix section: (Figure: B.1 , B.2 and B.3) in the Appendix Section.

4.2.2.1 Data Collection method

A baseline knowledge evaluation was conducted before the intervention. Then 4 rounds of physical card play were conducted. It was followed by a post-test using the questionnaire survey. A deck of cards was given to every 4-ASHA group who lived in close vicinity. They were encouraged to play when they met for about an hour every day for a week. After a week, the knowledge levels were again tested using the questionnaire survey.

4.2.3 Analysis and Results

In summary, knowledge levels were checked in three intervals: Pre-intervention, Immediately Post-intervention, and After a week. The summary of the results of the 3 tests is tabulated in Table: D.1 appended in the Appendix Section. The score data collected through the questionnaire survey is visualized through Box Plot in Figure: D.1. The histograms of score data collected at 3 intervals are visualized in distribution curves in Figure: E.1. The three histograms with distribution curves are combined in the Figure: E.2.

Before conducting any parametric tests on the data, normality or normal distribution of data should be checked. While there are multiple kinds of normality tests, the Anderson Darling Test is the most reliable and most commonly used. The test was performed for all 3 interval data/scores group. The P value was found to be greater than .05, which indicates that the data is normal. A reference to the normality test is shown in Figure E.3 in the Appendix section.

In order to check if there was a significant difference between scores, 1 sample paired t-tests between the scores was conducted. 3 groups were paired in combination of 2 and tested for significant difference. The results are tabulated in Table : E.4 in the Appendix section..

The pre-test scores differed significantly from both the post-tests, signifying a significant knowledge gain through the intervention (between the baseline survey and post-test survey). The mean difference between two score groups was found to be 6.37 . A test was conducted to check, at what difference of scores the improvement is significant. Starting from 1, the test was repeated by raising the difference and found that the difference is significant (95% CI) till >=5 but fails at 6. A reference to this paired t-test is shown in Figure E.5 in the Appendix section.

There was significant difference between the two post-tests (immediately after the intervention and a week after the intervention), but the p-value was less signifying very less loss of knowledge due to refreshing knowledge by playing with the cards throughout the week. The mean difference between two score groups was found to be 1. A test was conducted to check, at what difference of scores the improvement is significant. Starting from 0, the test was repeated by raising the difference and found that the difference is significant (95% CI) till <=0.5 but fails at 0.6. A reference to this paired t-test is shown in Figure E.6 in the Appendix section.

There were no statistical difference ($P > 0.7$) or high correlation (R^2 =0.00005) pattern found between factors like age, years of formal education, experience as an ASHA and the scores obtained in each tests or the delta learning between intervention phases.

All statistical analysis were performed in Minitab (Version 21.2) and the data or results are visualized using the website Flourish Studio.

4.2.4 Discussion

In summary, the playful activity with physical cards were found to be significantly effective for refresher training of ASHAs with significant knowledge retention. These results could be compared by repeating the experiment with the digital app.

There is a subtle trend which shows that with growing age the delta change in knowledge gains between pre and post test was getting lower. But in his research, the trend was not found

significant with a 95% confidence interval. Researches on learning in other contexts also find similar results. Years of formal education also has an insignificant effect on baseline score, as the knowledge or experience gained mostly depends on the years of experience, working in field as an ASHA worker and having a hands-on-experience dealing with the common issues. As a large number of ASHAs were in the category of 9-10 and more years of experience, a grouped comparison between them and the rest minority would not be statistically significant.

While checking the questionnaire survey, a lot of mismatch regarding standardization of information was found. 2 questions on Rotavirus were found to be ignored by a lot of ASHAs. On further investigation it was found that the Rotavirus vaccines were not operational in the entire state of Madhya Pradesh and thus also not included in the printed brochures. Some of the ASHAs made mistakes in PCV booster. On further investigation it was found that the term "booster" was not mentioned for any of the vaccines in the schedule they were trained with, thus arising confusion. But most of them understood and answered it right. 3 ASHAs were caught in the malpractice of cheating from their job aid immunization schedule during the baseline survey. They were excluded from the statistical evaluation calculations. In this study design, the same questionnaire was used for all 3 rounds of survey. In the next phase, the order of questions would be randomized to minimize the question's positional effect and order remembrance.

Some ASHAs, specially the ones with low formal education, faced difficulty with reading Hindi numbers printed on the cards as well as while filling the survey questionnaire. In the next phase the numbers would be changed to English and the words in Hindi unchanged. There were some ASHAs who studied in a Madrasa and could only recognise English and Urdu numbers. They required translation of the numbers in English in order to fill the form but still manged to play cards as the rest of the information on the card were enough to play.

Focused Group Discussions with ASHAs reveals a lot of information about their lives and daily activities, which usually gets masked behind the top-down bureaucratic framework, within which they work. Some of the ASHAs reported that the ANM is responsible for the immunization and the ASHA is mostly responsible for community mobilizing, co-ordinating and assisting with the ANM. In spite of that, any mistake committed by the ANM like wrong or missed immunization, not practicing standards of hygiene, is often blamed to the lower level vulnerable position, which in this case happens to be an ASHA. But still an ASHA does her best to provide the right kind of assistance required by the ANM and the community. If the ASHAs

could be trained with frequent refresher trainings, they could help minimize these faults in their daily job to a large extent, thus strengthening the community healthcare services. Most ASHAs have an intrinsic motivation to learn about healthcare and provide better care for the community. In spite of the selfless efforts put by the ASHAs, they used to be rarely appreciated by the state and sometimes by the community. Recently on 22 May 2022, the WHO Director-General has announced ASHAs of India as one of the six awardees of the Global Health Leaders Awards for their crucial role in linking the community with the health system and ensuring those living in rural poverty can access primary health care services in the crucial times of COVID-19 pandemic. The intention here is not to romanticize and idealize the lives and struggles of the ASHAs, but to highlight the immense amount of dedication they show towards their job in spite of often having physical fatigue and sometimes carrying emotional breakdowns as a woman and often also as a mother.

4.2.5 Limitations of the study

One of the limitations of this study is the gender, religion, class and caste positionality of the researcher vis-a-vis the ASHAs engaged in the study. The best practices and standards of research were followed including the community in iterative feedback loops to validate the collected data and its interpretation. As a future step there are plans to engage with multiple community stakeholders through our research insights to collaboratively explore if and how digital training interventions could be designed to enhance ASHAs refresher training, knowledge gains and retention.

The experiment was conducted in a formal institution environment of a healthcare centre. The job profile of the ASHAs, the participants or players of this experimental research are as voluntary field functionary or street level bureaucracy. ASHAs are a cadre of CHWs of the state, under which they are obiliged to act or function within the framework of the top-down bureaucracy.

4.2.6 Proposed Design of a Randomised Controlled Trial

We would like to repeat the experimental study again with the next cohort or recruit of ASHAs for evaluating the pedagogical impact and investigate the effect of demographics (ie, age, and socio-economic background), and study techniques on the long-term knowledge retention. The statistical results of conducting field experiments (n=30), the current study has led us to calculate the variables required for conducting a Randomized Control Trial (RCT).

Sample size was calculated by using G* power 3.0 software (Faul et al., 2007). In this study, comparisons between groups with t-tests (one tail) for independent samples, medium effect size (d = .50), a sample of 65 participants in each group would be required to achieve 99% power to detect difference at 0.05 significance level (Polit, 2014). For conducting 2 experiments with 2 groups (control and experiment), 130 participants would be required. Considering attrition rate of 10% during the phased experiment and evaluation process, the calculated sample size required to have a significant effect would be 145-150 ASHAs. A reference to the calculation is demonstrated in Figure E.7.

Pre, Post, and Long Term Post Tests (after 6 months) would be conducted to measure knowledge gained through playing sessions and retained for a long time. Game-related indicators like fun, engagement, satisfaction, and immersion will also be measured for both interventions.

Appendix A

Tables

Vaccine Name	Birth	$1\frac{1}{2} months$	$2\frac{1}{2} months$	$3\frac{1}{2} months$	9 months	$1\frac{1}{2} - 2 years$
BCG	✓					
Hepatitis B	✓					
OPV	✓	✓	✓	✓		✓
IPV		✓		✓		
Penta		✓	✓	✓		
PCV		✓		✓	✓	
Rota		✓	✓	✓		
MR					✓	✓
JE					✓	✓
DPT						✓

Table A.1: Child Immunization schedule

Appendix B

Survey Questionnaire

मैं अपनी हस्ताक्षर के माध्यम से स्वीकार करती हूं कि इस शोध अध्ययन में मेरी भागीदारी स्वैच्छिक है। मैं इस तथ्य से अवगत हूं कि एकत्र की गई व्यक्तिगत जानकारी का उपयोग केवल शैक्षिक उपयोग के लिए किया जाएगा।

_____ _____ / ____ / २०२२

हस्ताक्षर **तिथि**

नीचे दी हुई जगह पर अपना पूरा नाम लिखिए :

_____

अपनी उम्र लिखिए : _____ **साल**

आपकी स्कूली शिक्षा कौनसी श्रेणी तक हुई है :

☐ ८ वि ☐ ९ वि ☐ १० वि ☐ ११वी
☐ १२ वि ☐ ग्रेजुएट ☐ पोस्ट-ग्रेजुएट

आप कितने वर्षो से आशा कार्यकर्ता हैं :

_____ **साल**

कृपया निम्नलिखित प्रश्नों के उत्तर खाली बक्सों में ☑ निशान लगाकर दीजिये । प्रत्येक प्रश्न का केवल एक ही सही उत्तर है ।

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१. ओ पी वी - बूस्टर शिशु को किस आयु मै दिया जता है?

☐ ९ महीने ☐ ११/२ साल
☐ २ साल ☐ ३ १/२ साल

२. पेंटावैलेंट - १ टीका शिशु को किस आयु मै दिया जता है?

☐ ११/२ महीने ☐ २ १/२ महीने
☐ ३ १/२ महीने ☐ ९ महीने

३. एम आर - १ (खसरे का पहला टीका) शिशु को किस आयु मै दिया जता है?

☐ ९ महीने ☐ ११/२ साल
☐ २ साल ☐ ३ १/२ साल

४. पहला डीपीटी बूस्टर शिशु को किस आयु मै दिया जता है?

☐ ९ महीने ☐ ११/२ साल
☐ २ साल ☐ ३ १/२ साल

५. दूसरा डीपीटी बूस्टर शिशु को किस आयु मै दिया जता है?

☐ ९ महीने ☐ ११/२ साल
☐ ५-६ साल ☐ ३ १/२ साल

६. टी टी / टी डी (टेटनेस / डिप्थोरिया) का पहला टीका शिशु को कौनसी आयु मे दिया जाता है?

☐ १० साल ☐ १६ साल
☐ ६ साल ☐ ५ साल

७. टी टी / टी डी (टेटनेस / डिप्थोरिया) का दूसरा टीका शिशु को कौनसी आयु मे दिया जाता है?

☐ १० साल ☐ १६ साल
☐ ६ साल ☐ ५ साल

८. पेंटावैलेंट - २ टीका शिशु को किस आयु मै दिया जता है?

☐ ११/२ महीने ☐ २ १/२ महीने
☐ ३ १/२ महीने ☐ ९ महीने

Figure B.1: Questionnaire Page-1

९. विटामिन ए सबसे पहले बच्चों को कब दिया जाता है?

☐ ९ महीने ☐ १ १/२ साल

☐ २ साल ☐ ३ १/२ साल

१०. विटामिन ए दूसरी बार बच्चों को कब दिया जाता है?

☐ ९ महीने ☐ १ १/२ साल

☐ २ साल ☐ ३ १/२ साल

११. दूसरी बार के बाद विटामिन ए बच्चों को किस अंतराल में दिया जाता है?

☐ ३ महीने ☐ ४ महीने

☐ ५ महीने ☐ ६ महीने

१२. एम आर - २ (खसरे का दूसरा टीका) शिशु को कब दिया जता है?

☐ ९ महीने ☐ १ १/२ साल

☐ २ साल ☐ ३ १/२ साल

१३. जे ई - १ (जापानीज इन्सेफेलाइटिस) का पहला टीका शिशु को कब दिया जाता है?

☐ ९ महीने ☐ १ १/२ साल

☐ २ साल ☐ ३ १/२ साल

१४. जे ई - २ (जापानीज इन्सेफेलाइटिस) का दूसरा टीका शिशु को कब दिया जाता है?

☐ ९ महीने ☐ १ १/२ साल

☐ २ साल ☐ ३ १/२ साल

१५. पी सी वी - १ (न्यूमोकोकल कंजुगेट) का पहला टीका शिशु को कब दिया जाता है?

☐ १ १/२ महीने ☐ २ १/२ महीने

☐ ३ १/२ महीने ☐ ९ महीने

१६. पी सी वी - २ (न्यूमोकोकल कंजुगेट) का दूसरा टीका शिशु को कब दिया जाता है?

☐ १ १/२ महीने ☐ २ १/२ महीने

☐ ३ १/२ महीने ☐ ९ महीने

१७. पी सी वी - बूस्टर शिशु को कब दिया जता है?

☐ १ १/२ महीने ☐ २ १/२ महीने

☐ ३ १/२ महीने ☐ ९ महीने

१८. पेंटावैलेंट - ३ टीका शिशु को किस आयु मै दिया जता है?

☐ १ १/२ महीने ☐ २ १/२ महीने

☐ ३ १/२ महीने ☐ ९ महीने

१९. हेपेटाईटिस बी टीका शिशु को कब दिया जता है?

☐ जन्म ☐ १ १/२ महीने

☐ २ महीने ☐ ३ १/२ महीने

२०. रोटा - १ (रोटावायरस) का पहला टीका शिशु को कब दिया जता है?

☐ जन्म ☐ १ १/२ महीने

☐ २ महीने ☐ ३ १/२ महीने

२१. बी सी जी का टीका शिशु को कब दिया जता है?

☐ जन्म ☐ १ १/२ महीने

☐ २ महीने ☐ ३ १/२ महीने

२२. रोटा - २ (रोटावायरस) का दूसरा टीका शिशु को कब दिया जता है?

☐ जन्म ☐ १ १/२ महीने

☐ २ महीने ☐ ३ १/२ महीने

२३. ओ पी वी - ० (ओरल पोलियो वैक्सीन) का पहला टीका शिशु को कब दिया जता है?

☐ जन्म ☐ १ १/२ महीने

☐ २ महीने ☐ ३ १/२ महीने

२४. रोटा - ३ (रोटावायरस) का तीसरा टीका शिशु को कब दिया जता है?

☐ जन्म ☐ १ १/२ महीने

☐ २ महीने ☐ ३ १/२ महीने

२५. जन्म के तुरंत बाद शिशु को क्या दिया जाना चाहिए?

☐ कोलोस्ट्रम ☐ ओ पी वी - ०

☐ हेपेटाईटिस बी ☐ बी सी जी का टीका

Figure B.2: Questionnaire Page-2

२६. ओ पी वी - १ (ओरल पोलियो वैक्सीन) का दूसरा टीका शिशु को कब दिया जता है?

⬜ जन्म ⬜ १ १/२ महीने

⬜ २ महीने ⬜ ३ १/२ महीने

२७. आई पी वी - १ (इनएक्टिवेटेड पोलियो वैक्सीन) का पहला टीका शिशु को कब दिया जता है?

⬜ जन्म ⬜ १ १/२ महीने

⬜ २ महीने ⬜ ३ १/२ महीने

२८. ओ पी वी - २ (ओरल पोलियो वैक्सीन) का दूसरा टीका शिशु को कब दिया जता है?

⬜ जन्म ⬜ १ १/२ महीने

⬜ २ महीने ⬜ ३ १/२ महीने

२९. पेंटावैलेंट - २ टीका शिशु को किस आयु मै दिया जता है?

⬜ ९ महीने ⬜ १ १/२ साल

⬜ २ साल ⬜ ३ १/२ साल

३०. ओ पी वी - ३ (ओरल पोलियो वैक्सीन) का दूसरा टीका शिशु को कब दिया जता है?

⬜ जन्म ⬜ १ १/२ महीने

⬜ २ महीने ⬜ ३ १/२ महीने

३१. आई पी वी - २ (इनएक्टिवेटेड पोलियो वैक्सीन) का पहला टीका शिशु को कब दिया जता है?

⬜ जन्म ⬜ १ १/२ महीने

⬜ २ महीने ⬜ ३ १/२ महीने

३२. एक गर्भवती माँ को अपनी पूरी गर्भावस्था में कितने न्यूनतम प्रसवपूर्व देखभाल सत्रों की आवश्यकता होती है ?

⬜ १ ⬜ २

⬜ ३ ⬜ ४

३३. किस प्रसवपूर्व देखभाल पर गर्भवती माँ को टी टी - १ (टिटनेस टॉक्साइड) का पहला इंजेक्शन दिया जाता है ?

⬜ पहला ⬜ दूसरा

⬜ तीसरा ⬜ चौथा

३४. किस प्रसवपूर्व देखभाल पर गर्भवती माँ को टी टी - २ (टिटनेस टॉक्साइड) का दूसरा इंजेक्शन दिया जाता है ?

⬜ पहला ⬜ दूसरा

⬜ तीसरा ⬜ चौथा

३५. टीटी बूस्टर उन गर्भवती माताओ को दी जाती है जिन्होने पिछले कितनी सालो में टीटी के २ टीके लगवा चुकी है ?

⬜ १ ⬜ २

⬜ ३ ⬜ ४

३६. किस प्रसवपूर्व देखभाल पर गर्भवती माँ को आयरन फोलिक एसिड (आई एफ ए) की गोलियां सेवन चालू करनी चाहिए ?

⬜ पहला ⬜ दूसरा

⬜ तीसरा ⬜ चौथा

३७. गर्भवती महिलाओं को कौन सी कृमिनाशक गोली दी जाती है ?

⬜ कैल्शियम ⬜ एल्बेंडाजोल

⬜ आई एफ ए ⬜ विटामिन डी

३८. आई एफ ए गोलि के साथ किस गोलि का सेवन नहीं करना चाहिए ?

⬜ कैल्शियम ⬜ एल्बेंडाजोल

⬜ आई एफ ए ⬜ विटामिन डी

३९. सिफलिस टेस्ट और एचआईवी टेस्ट किस प्रसवपूर्व देखभाल पर गर्भवती माँ को करवाना चाहिए ?

⬜ पहला ⬜ दूसरा

⬜ तीसरा ⬜ चौथा

४०. पहला प्रसव पश्चात देखभाल कितने घंटों के भीतर करना चाहिए?

⬜ ४ ⬜ ६

⬜ १२ ⬜ २४

Figure B.3: Questionnaire Page-3

Appendix C

Participants Demographics

Parameters	Number of ASHAs (%)
Age	
< 30	1 (3.33%)
30 - 39	16 (53.33%)
40 - 49	12 (40.00%)
50 and above	1 (3.33%)
Formal Education (grade)	
10^{th} grade	8 (26.66%)
11^{th} - 12^{th} grade	8 (26.66%)
Graduation	11 (36.66%)
Post-Graduation	3 (10.00%)
Experience as an ASHA worker (years)	
2 - 5	8 (26.66%)
9	6 (20.00%)
10	16 (53.33%)

Table C.1: Participants Demographics (Age, Formal Education, and Experience as an ASHA)

Appendix D

Data Collected

Intervention	Pre-test	Post-test	Post-test after a week
N	30	30	30
Mean Score	19.70	26.07	25.07
Standard Deviation (SD)	5.21	4.53	4.69
P (Normality Test)	0.614	0.635	0.410
1st Quartile	17	23.75	22
Median	19.5	26	25
3rd Quartile	22.75	29.25	27.5
Inter Quartile Range	5.75	5.5	5.5
Minimum	9	17	14
Maximum	30	36	35
Skewness	-0.20	-0.26	-0.20
Kurtosis	0.19	0.62	0.57

Table D.1: Comparison of Pre-test, Post-test, and Post-test (after one week) scores. Learning through playing with Physical cards in groups of 4

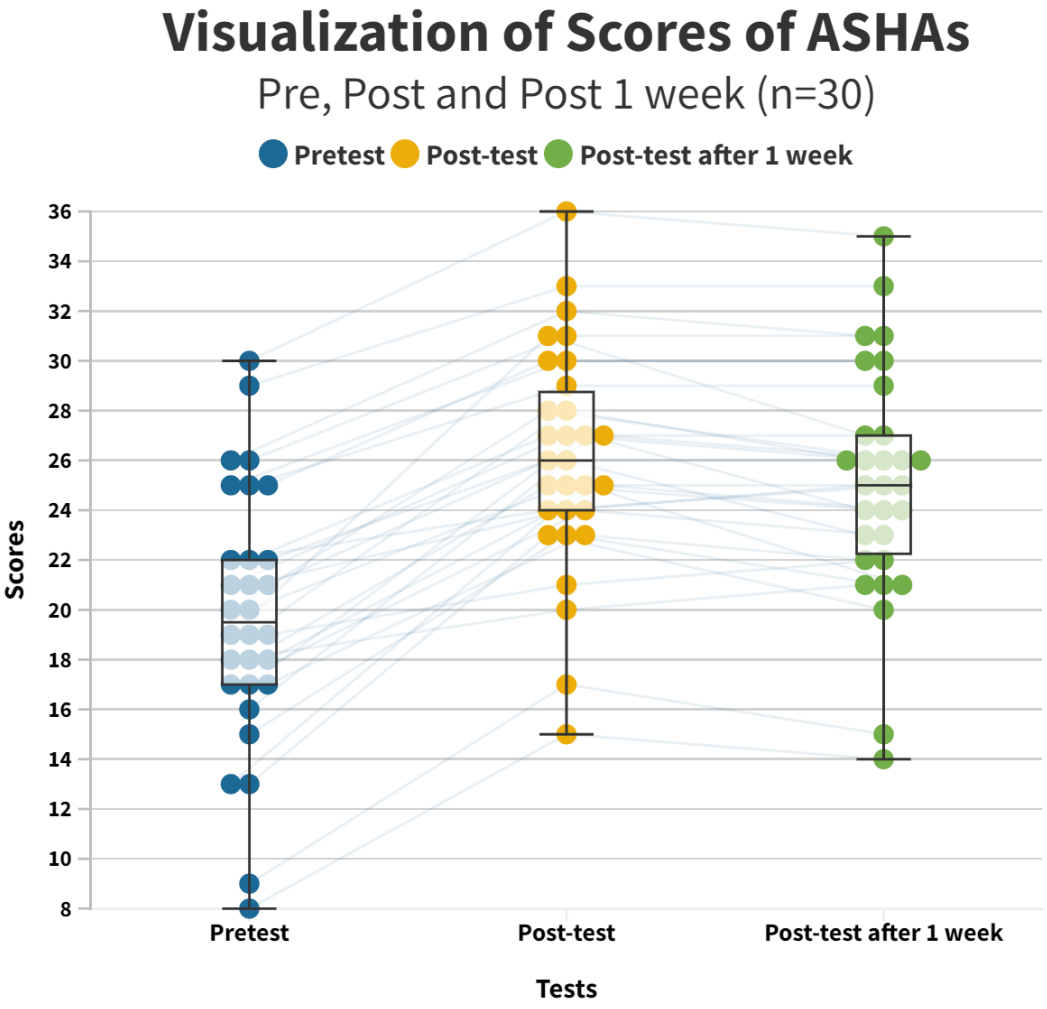
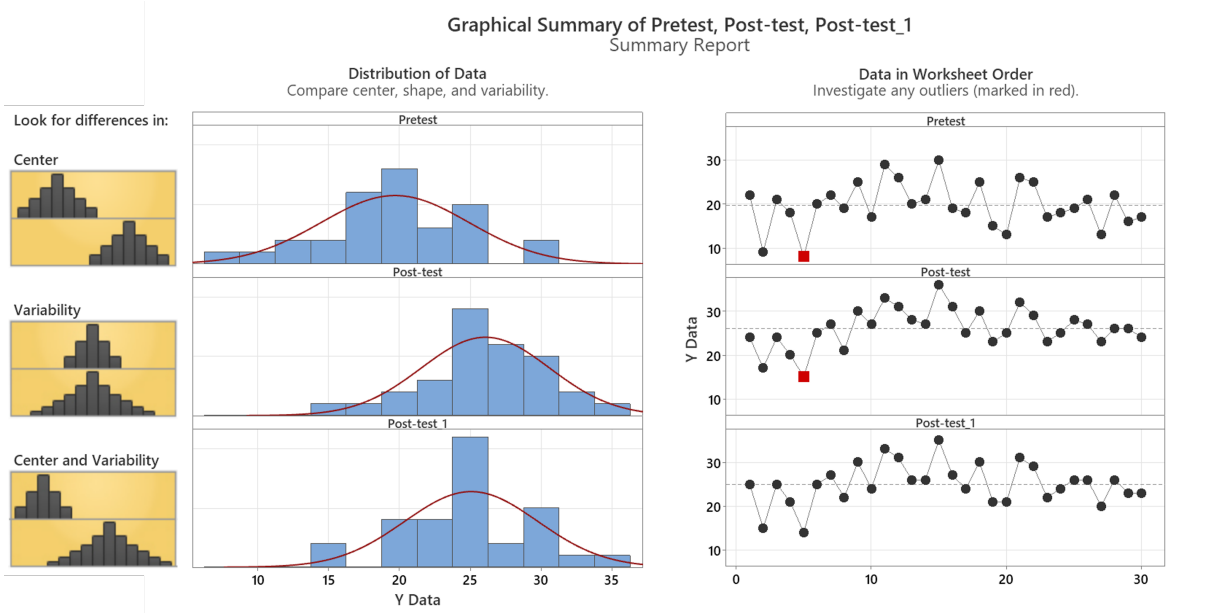


Figure D.1: Comparison of Pre-test, Post-test, and Post-test (after one week) scores



Group	N	Mean	95% CI	StDev	95% CI	Min	Median	Max	Normality Test P	Normality Test Decision
Pretest	30	19.7	(17.756, 21.644)	5.2071	(4.1470, 7.0000)	8	19.5	30	0.614	Pass
Post-test	30	26.067	(24.377, 27.756)	4.5253	(3.6040, 6.0834)	15	26	36	0.635	Pass
Post-test_	30	25.067	(23.315, 26.818)	4.6899	(3.7351, 6.3047)	14	25	35	0.410	Pass

Figure D.2: Summary of 3 groups

Appendix E

Data Analysis and Results

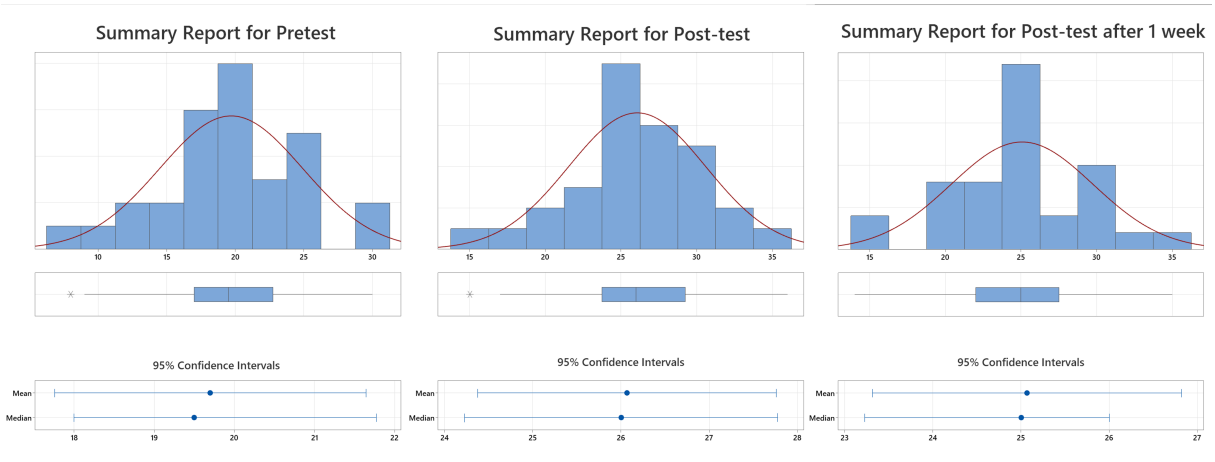


Figure E.1: Comparison of distributions between Pre-test, Post-test, and Post-test (after one week) scores

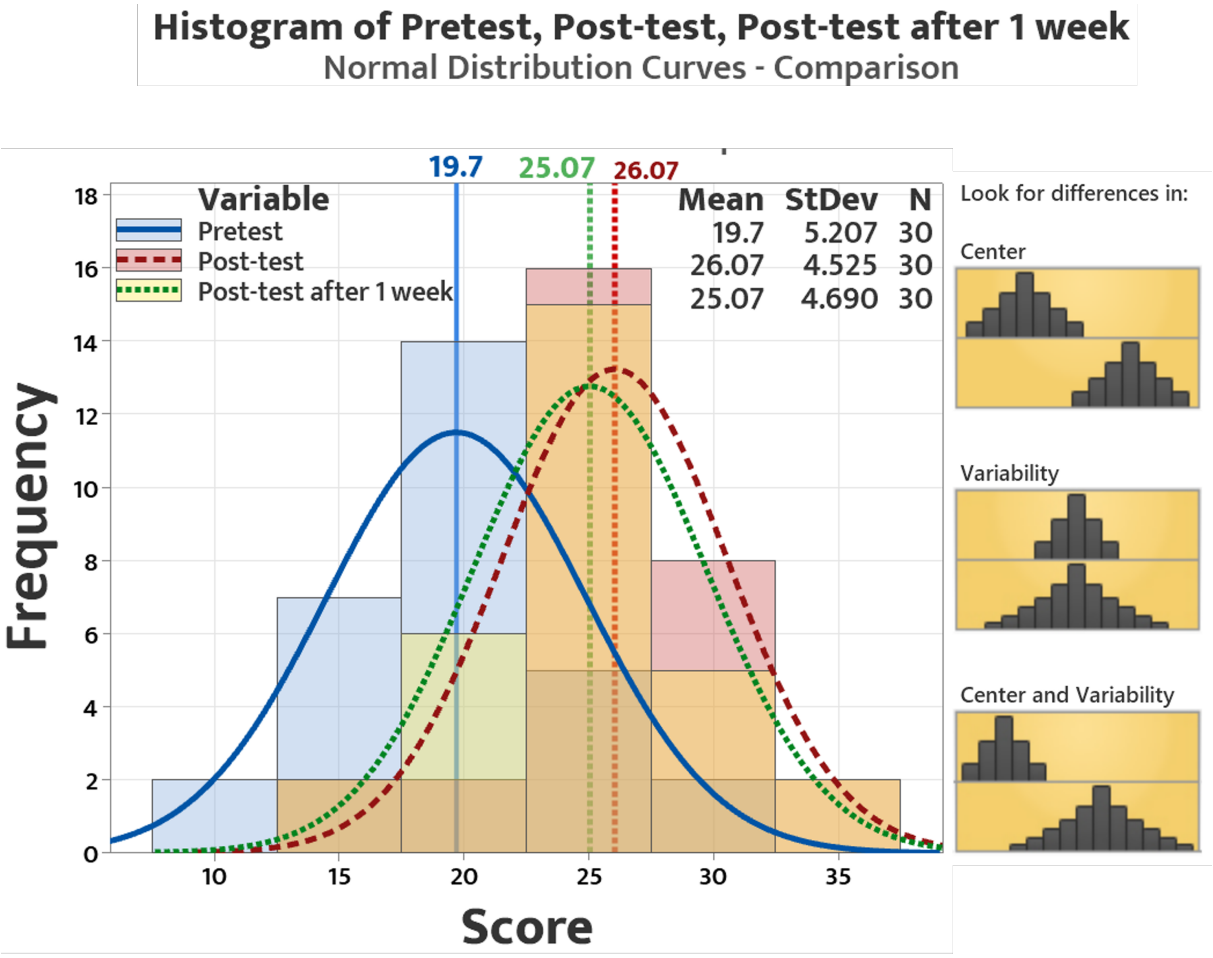


Figure E.2: Combination of above 3 histograms

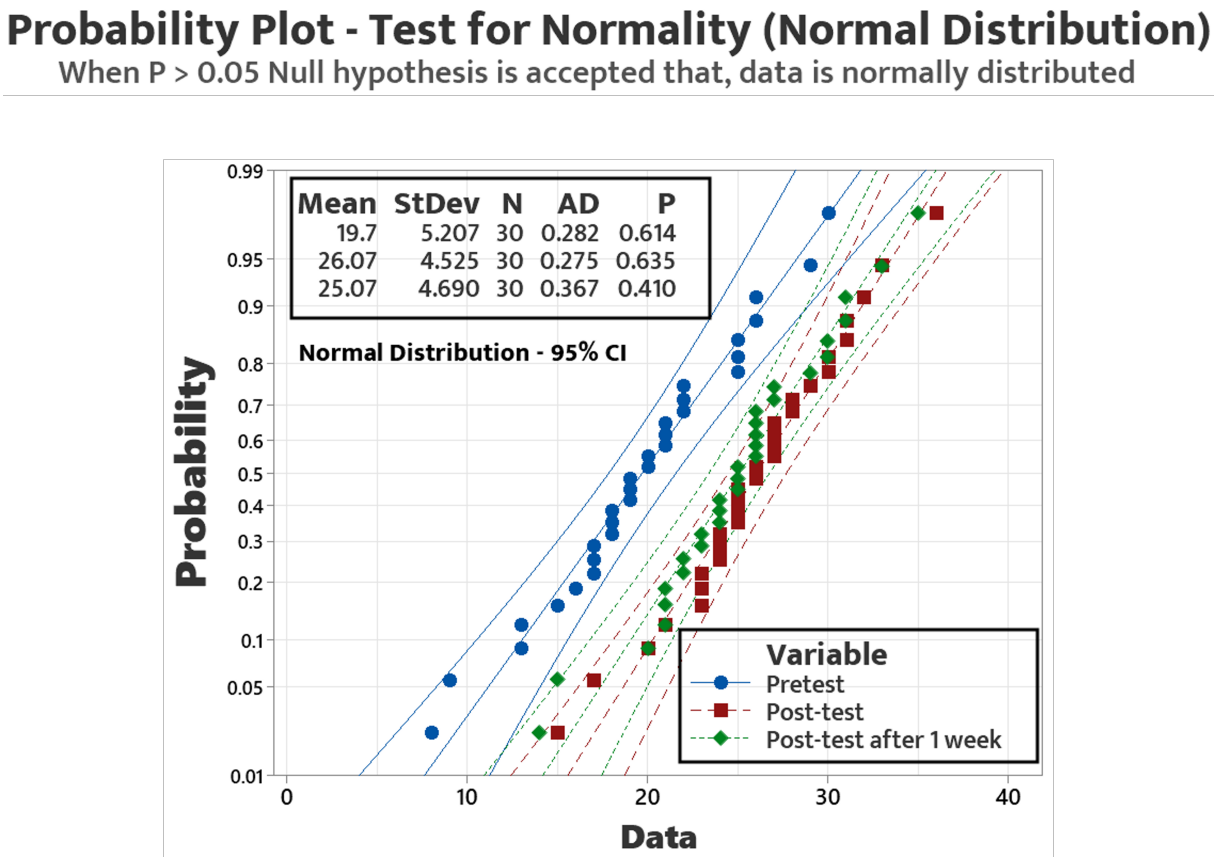


Figure E.3: Comparison of normality or Normal Distribution using Anderson Darling Test between Pre-test, Post-test, and Post-test (after one week) scores

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Post-test	26.0667	30	4.52528	.82620
	Pretest	19.7000	30	5.20709	.95068
Pair 2	Post-test after 1 week	25.0667	30	4.68993	.85626
	Pretest	19.7000	30	5.20709	.95068
Pair 3	Post-test after 1 week	25.0667	30	4.68993	.85626
	Post-test	26.0667	30	4.52528	.82620

Paired Samples Correlations

		N	Correlation
Pair 1	Post-test & Pretest	30	.853
Pair 2	Post-test after 1 week & Pretest	30	.968
Pair 3	Post-test after 1 week & Post-test	30	.954

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	Post-test - Pretest	6.36667	2.72262	.49708	5.35002	7.38331	12.808	29	.000
Pair 2	Post-test after 1 week - Pretest	5.36667	1.35146	.24674	4.86202	5.87131	21.750	29	.000
Pair 3	Post-test after 1 week - Post-test	-1.00000	1.41421	.25820	-1.52808	-.47192	-3.873	29	.001

Figure E.4: Results from Paired T-tests between Pre-test, Post-test, and Post-test (after one week) scores

Paired T-Test and CI: Post-test, Pretest

Descriptive Statistics

Sample	N	Mean	StDev	SE Mean
Post-test	30	26.067	4.525	0.826
Pretest	30	19.700	5.207	0.951

Estimation for Paired Difference

Mean	StDev	SE Mean	95% Lower Bound for μ_difference
6.367	2.723	0.497	5.522

μ_difference: population mean of (Post-test - Pretest)

Test

Null hypothesis	H_0: μ_difference = 5
Alternative hypothesis	H_1: μ_difference > 5

T-Value	P-Value
2.75	0.005

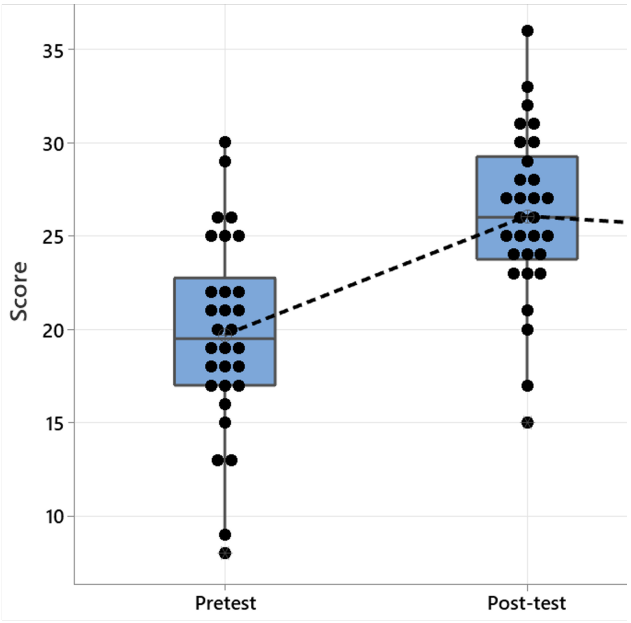


Figure E.5: Results from Paired T-tests between Pre-test, Post-test scores

Paired T-Test and CI: Post-test after 1 week, Post-test

Descriptive Statistics

Sample	N	Mean	StDev	SE Mean
Post-test after 1 week	30	25.067	4.690	0.856
Post-test	30	26.067	4.525	0.826

Estimation for Paired Difference

Mean	StDev	SE Mean	95% Upper Bound for μ_difference
-1.000	1.414	0.258	-0.561

μ_difference: population mean of (Post-test after 1 week - Post-test)

Test

Null hypothesis	H_0: μ_difference = -0.5
Alternative hypothesis	H_1: μ_difference < -0.5

T-Value	P-Value
-1.94	0.031

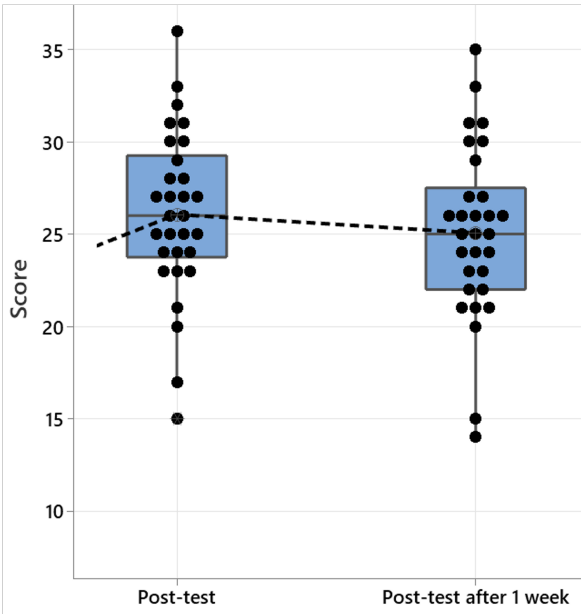


Figure E.6: Results from Paired T-tests between Post-test, and Post-test (after one week) scores

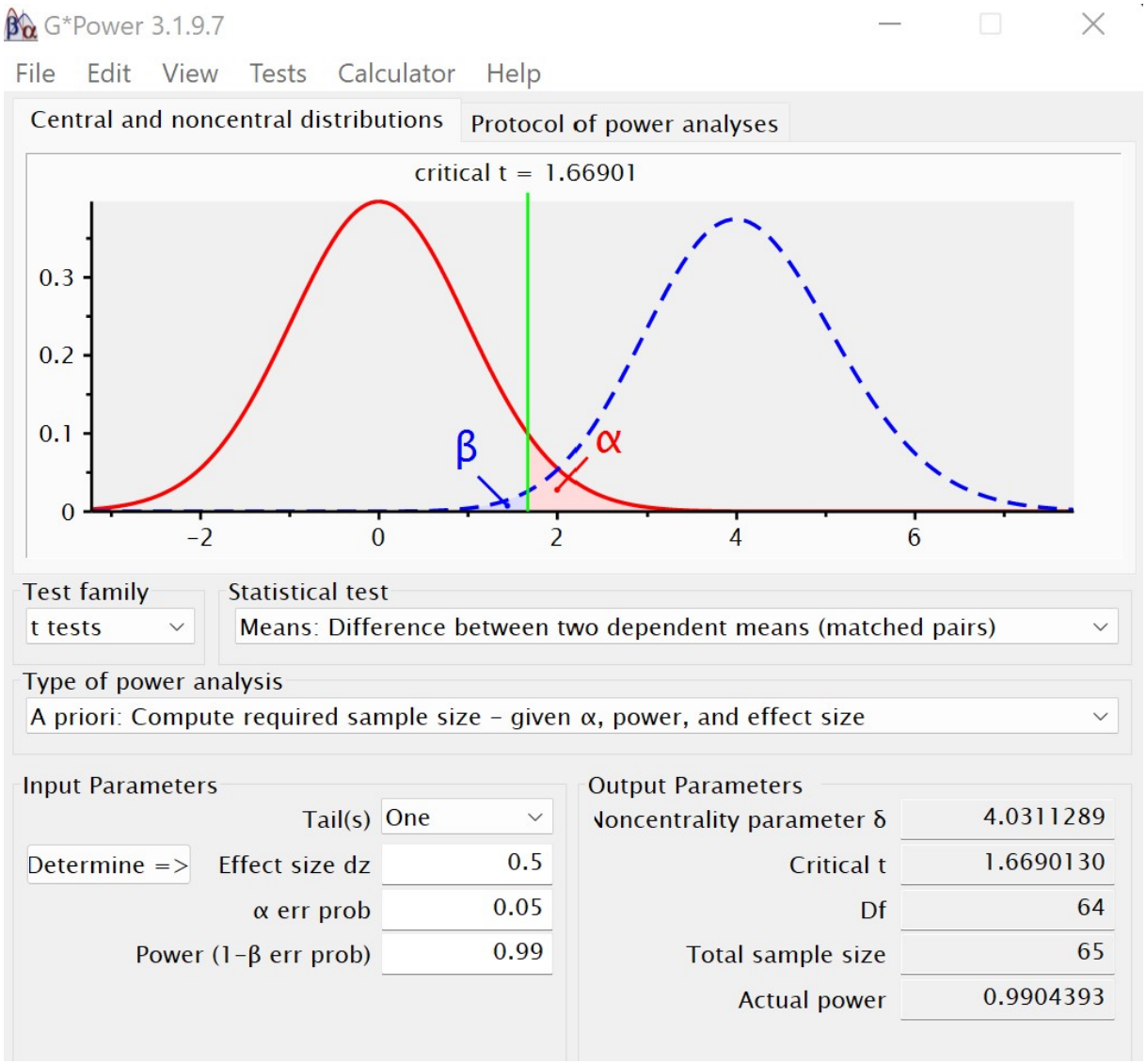


Figure E.7: Sample calculation for paired t-test, given alpha, power and effect size

Appendix F

Field Images from Burhanpur

Figure F.1: Baseline survey - Evaluation of prior-knowledge

Figure F.2: 4-ASHAs group playing with physical cards

Figure F.3: Focused Group Discussion after the ASHAs complete play-testing rounds

Figure F.4: A group photo with the ASHAs, the ASHA coordinator, the facilitator (Amit Kumar Ukey), and the researcher

Appendix G

The designed deck of cards

Figure G.1: Immunization cards for children below 1 year (continued on next page)

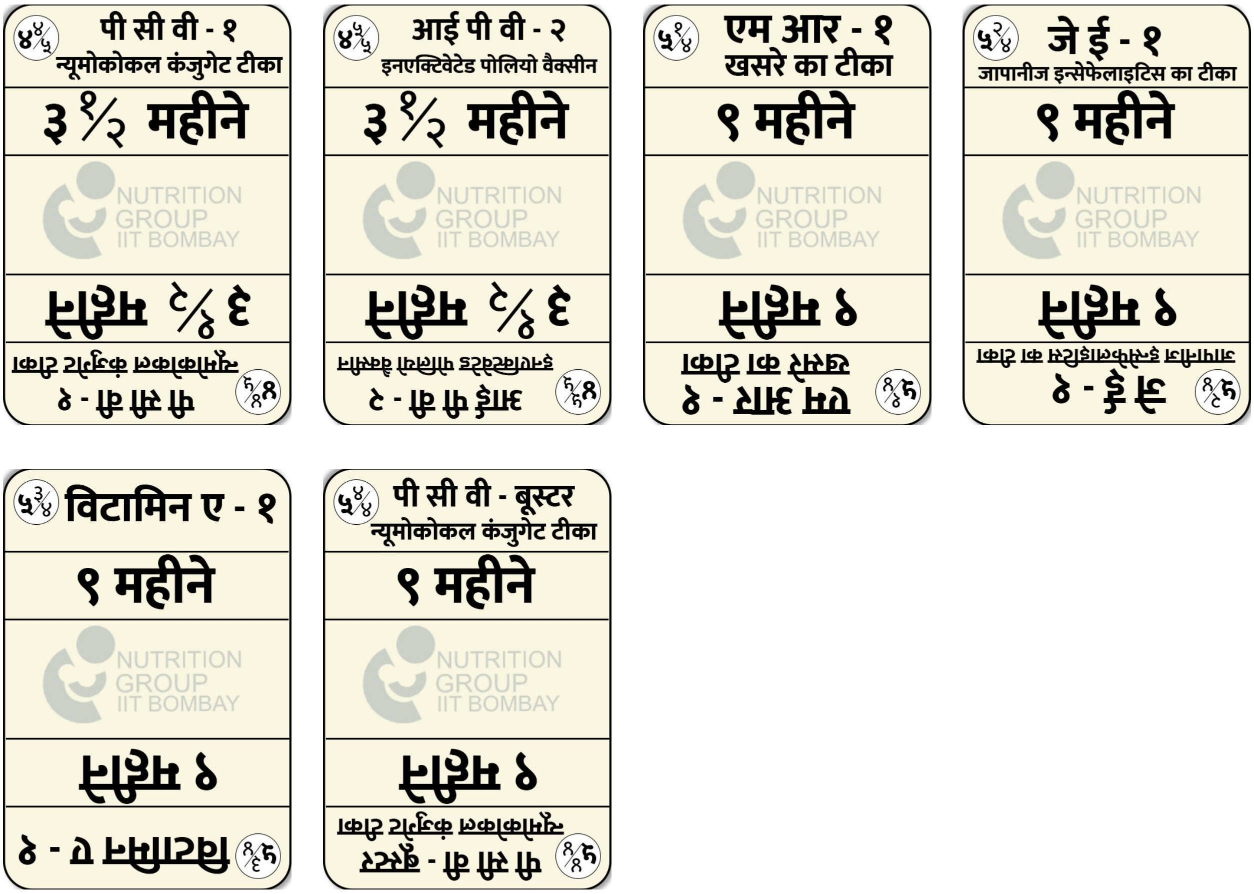


Figure G.2: Immunization cards for children below 1 year (continued from previous page)

Figure G.3: Immunization cards for children above 1 year

Figure G.4: Ante-Natal-Care (ANC)

Figure G.5: Post-Natal-Care (PNC)

Appendix H

Mobile app Screenshots

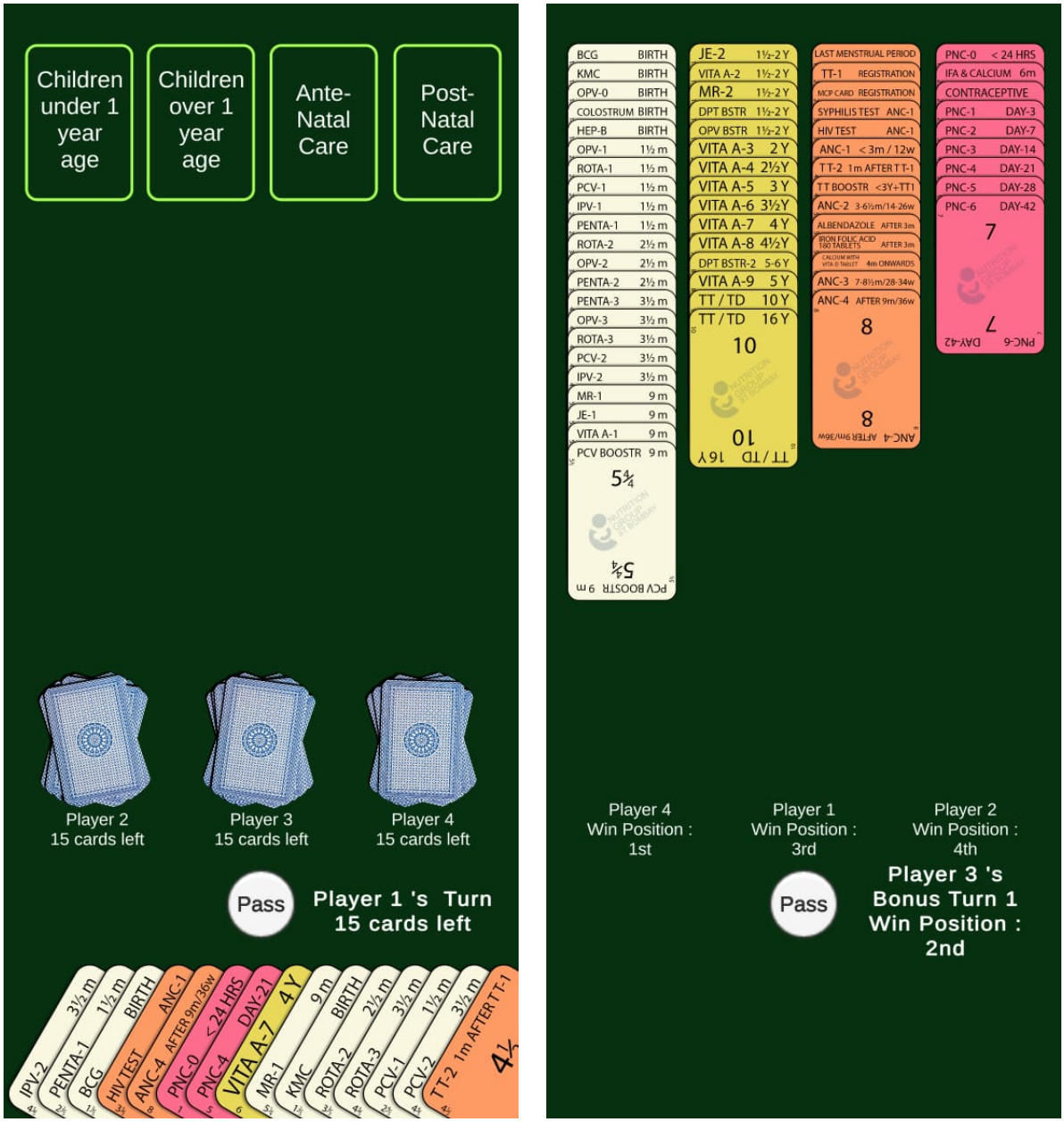


Figure H.1: Mobile app Screenshot - Play Start and End Screen

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List of Publications

International Conferences

1. **Majhi, A.**, Mondal, A., Joshi, A., Agnihotri, S. B., 2021. Refresher Training through Quiz App for capacity building of Community Healthcare Workers or Anganwadi Workers in India. ", *CHI 2021 : Asian CHI Symposium 2021, Virtual, Yokohama, Japan, May 2021*, ACM International Conference Proceeding Series.
   https://dl.acm.org/doi/10.1145/3429360.3468186
   (Best Paper award in Long Paper category)

2. **Majhi, A.**, Agnihotri, S. B., Mondal, A., 2021. Physical and Augmented Reality based Playful Activities for Refresher Training of ASHA Workers in India ", *CHI 2022 : Asian CHI Symposium 2022, Virtual, New Orleans, LA, April 2022*, ACM International Conference Proceeding Series.
   https://dl.acm.org/doi/10.1145/3516492.3558788
   (Gary Marsden Travel Grant Award for attending the CHI 2022 conference in person)
   (Best Paper and Best Presentation award in Long Paper category)

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