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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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**.

Examiners:

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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 and et.al., 2017; Yadav et al., 2019; Yadav and et.al., 2019). This research builds on and contributes to the previous research studies conducted by Indian researchers on making games and gamified systems (Majhi et al., 2021b; Tulaskar, 2020) for training Community Healthcare Workers.

The perception of classroom-based training for CHWs has been that it is boring or non-engaging. It prompted many researchers to explore strategies for making training and learning more enjoyable. While learning through games may not guarantee complete comprehension of a subject, it often serves as a significant motivator. Although the literature on creating enjoyable learning experiences is extensive, there is limited direct evidence connecting fun and enjoyment in game-based learning to improved learning outcomes. However, game-based learning is believed to enhance engagement, which in turn can foster better learning. Various strategies have been employed to achieve this, including the use of diverse media, entertaining instructional

methods, and hands-on constructivist approaches. The boundary between enjoyment and education is not always clear. Interestingly, in many cases, learning becomes a byproduct of enjoyable activities.

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 immediate knowledge improvement (pre-post test)
    - Tests for knowledge retention (pre and long-post test)
    - Heuristic Evaluation
    - System Usability Scale (SUS) test
    - Game Experience Questionnaire (GEQ)
    - Intrinsic Motivation Inventory (IMI) test for Intrinsic Motivation
- 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 (Telecom Regulatory Authority of India, 2021), out of the 1205.64 million telephone subscribers as on June 30, 2024 in India, 44.66% (538.51 million) were rural telephone subscribers. Out of them, 99.44% (535.53 million) were rural wireless telephone subscribers making 45.75% share of the total wireless subscribers. Based on NSS 75th Round, Household Social Consumption Education Survey conducted between July 2017-June 2018 (MoSPI, 2015), it was found that 35.8% households (24.8% rural and 51.3% urban) had access to 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. On 14 May 2021, Union cabinet minister, Smriti Irani tweeted that over 1.405 million Anganwadi workers have downloaded Poshan Tracker, the Women and Child Development Ministry's app to track nutrition delivery services. 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 (1st Level), improvement in learning (2nd Level), improvement in behaviour (3rd Level) and training outcome or results (4th 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 healthcare 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, 2016). 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 and 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. The possibilities of playing 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 sparse.

The core learning objective of the game is that the community health workers memorize the sequence and dosage of immunizations and supplements required by the child and mother. Initially, there were thoughts 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. However, 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: Children below 1yr (n=22), Children above 1yr (n=15), ANC (n=14) 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 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. 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 considering a 4-player round. The mathematical expression of the number of permutations possible for each player's hand considering 4 player round is as follows: 60! / (15! X 15! X 15! X 15!) or simplified $\frac{60!}{(15!)^4}$. Google Sheet Expression =FACT(60)/POW(FACT(15),4) which calculates to an astronomical value of 2,845,616,726,065,970,000,000,000,000,000,000

3.6 Designing Challenges, Mechanics and Rules of Play

In the process of game design, after brainstorming the basic game idea of stacking cards as per schedule, we focused on methods to translate content elements of immunization into game elements. We can call this as translation phase. This helped towards achieving endogenousness in design, where game mechanics and resources emerged directly from the immunization content itself.

We started with reimagining content elements as game elements. In the designed game, the immunization content was represented by the vaccines, which act as resources in the game. Each vaccine (such as polio, measles, or tetanus) becomes a game resource that players must acquire and administer at the correct time, simulating the real-world immunization schedule.

The designed game involved players stacking "vaccine cards" in chronological order based on when each vaccine needs to be administered according to a child's age. Players would have

to strategically decide which vaccines to prioritize, mirroring real-world challenges faced by CHWs in ensuring timely immunizations. These vaccine cards were color-coded or labeled to correspond to specific diseases, time of intervention (in months), and players received points or rewards for correctly stacking the cards in line with a virtual child's immunization needs.

Our strategy of choosing Game Mechanics, firstly involved identifying player actions that can be performed with the game's resources, while the other strategy mapped established mechanics onto content elements. By linking well-known mechanics with content-derived resources on immunization, we tried to develop a system that feels more naturally connected to immunization or the game's subject matter.

We also focused on opposition mechanics or obstructions or opposing forces within the content of immunization. In moderately advanced level of the game, the mechanics were included in form of unforeseen challenges like a vaccine shortage, requiring players to trade or manage limited resources, or a simulated disease outbreak that necessitates quick decision-making to administer booster shots. This created dynamic decision-making and action elements that reflect the content of immunization, transforming real-world health information into an engaging and educational game format. Challenges often arise when opposition mechanics are not apparent in the content, leading to exogenous mechanics. However, these challenges can also inspire creative solutions and novel opposition mechanics.

Endogenous design arises when resources or mechanics are organically derived from the content. However, when we were unable to synthesize mechanics or resources directly from content, we resorted to exogenous mechanics, using designs like races or other standard systems. These choices might lead to a more disjointed relationship between content and gameplay.

Once a core or opposition mechanic (blocking cards to restrict completing the sequence) has been identified, we followed the Mechanics-Dynamics-Aesthetics (MDA) framework by (Fabricatore Carlo, 2007). The translation of content to game elements, particularly through mechanics and resources, steered whether the design remains endogenous or shifts towards exogenous approaches.

In game-based learning, effective translation of content into game elements enables the delivery of learning through a variety of channels. These include visual elements (4 foundation layout demonstrating 4 silos of mother and child care mainly focusing on immunization), action

elements (game mechanics like stacking of cards and ordering), information elements (Card details like name of immunization and time of intervention), and decision elements (player choices during the gameplay). Each of these elements contributes to how players interact with the game, allowing learning to emerge organically from engagement with the game system.

However, knowledge acquisition through game based learning presents significant challenges, especially when introducing novel concepts. Research, including our previous studies (Majhi et al., 2021a, 2022, 2024c,a,b), and those of Ke (2016), shows that activating prior knowledge is meaningful and sometimes easier rather than facilitating the acquisition of new knowledge. Designing games for novel knowledge is particularly difficult in complex subjects like immunization concepts.

Thus, while games can be highly effective for knowledge reinforcement and application, they are less frequently successful in facilitating the acquisition of entirely new knowledge, particularly in cases where the content is abstract or requires sensory engagement for full comprehension. However in our designed game we restricted our content to only factual information, and learning through simple game mechanics was an appropriate choice.

3.7 Rules of Play

- 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 onto 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 acts 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 being placed or 2 bonus rounds are complete, then the

turn goes to the next/following player.

- After one age group is completed, 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.

3.8 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. However, 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.

3.9 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 the 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.

3.10 Multiplayer Playing Variation

During previous field studies, it was observed that more than half of the ASHAs had access to smartphones but did not own them. Usually, their husbands own it and share it with their wives, the ASHA. The resource constraints of owning a phone individually could be potentially solved if one smartphone could be used by 4 players, turn by turn while 4 players can physically arrange them sitting in a circle. A pass button in the User Interface to skip the turn to the next player was introduced. After each player plays her move in her turn and ends 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 which player's turn is it currently.

During previous field studies, it was also observed that the Community Healthcare Workers are comparatively busy during their daytime serving the community, going door to door. It becomes hard for them to manage time to physically get together, sit in a circle, and play the game either digitally or physically. A multiplayer remotely connected play would potentially solve this problem. In this case, one of the players creates a server generally called a "Room" having a meaningful name representing the team. The rest of the players connect to that room and the creator of the room starts the game. Similar mechanics are followed. The players get an opportunity to put cards in their turn. When the turn is passed, the moves get frozen until the

turn comes all over again completing all the other players.

During trials, with remotely connected players we observed that there were a lot of misunderstandings due to the lack of communication between players. They felt frustrated if they couldn't perform a task due to the restrictions enforced by the rules of play, for example when the turn was missed or couldn't place a card in their turn, etc. So we introduced audio communication similar to a radio which broadcasts audio of one player to all other players connected in the room or with the other player forming a group with the player. We observed peer learning happening through the discussions between the players while explaining the rules to one another and in general team conversations.

Following the same game mechanics, rules, and deck of cards, two variations of the Android game app were developed. The gameplay analytics of each player were 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 have 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, we were able 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 generally follows 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. The GEQ or Game Experience Questionnaire (Ijsselsteijn et al., 2013) was translated into Indian languages. We started with Marathi and Hindi as the respondents were majorly into these two languages.

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. To compare if the delta learning is significantly different in one of the cases, a paired 2-sample t-test (considering normal distribution) was conducted. The post-test was further compared to another post-test done a week later to compare knowledge retention. Similar t-tests were conducted to find significant differences.

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

Level 3 or Behavior changes can be examined by shadowing the CHWs in immunization camps and understanding the knowledge and attitude about immunization, pre and post-intervention. Qualitative studies like coding the daily experiences of each persona, might show some changes. Level 4 changes can be examined by checking changes in the percentage of child immunization in large health surveys conducted pre and post-intervention, would have too many co-factors, and measuring the changes would not be exclusive of the intervention.

Apart from learning gains and knowledge retention tests, we performed usability testing and other qualitative evaluations of this teaching and learning method.

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 learned, 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, providing context for social interaction, etc?

4.1.1 Participants

Prior notification of conducting these field testing sessions was given to the ASHA coordinator and Health Officers of Burhanpur Urban (Burhanpur, Madhya Pradesh), Joka village (Kolkata, West Bengal), and Mandala village (Slum near BARC, Mankhurd, Mumbai). ASHAs were recruited in this research through snowball sampling (Goodman, 1961). The demographics of the participants are tabulated in Table: C.1.

Another arm of the experiment was conducted among nursing students of 2 years of ANM and 4 years of Bsc Nursing at the Seva Mandal Education Society's, Smt. Sunanda Pravin Gambhirchand College of Nursing, located at Matunga, Mumbai.

The last arm compared grouped performance of ASHA and AWWs. G-power Faul et al. (2007) was used for sample size calculation. The effect size convention (d)=0.5, power (1-β)=0.95, and level of significance (α)=0.05 was chosen. The calculated sample size is 88 for each arm. Considering the 10% attrition rate, 97 100 participants were required for each of the four groups (consisting of 50 ASHAs and 50 AWWs for each group). CHW supervisors were contacted, and 200 ASHAs and 200 AWWs were selected through convenience sampling. Till the end of the study, 184 ASHAs and 184 AWW were retained (46 ASHAs and 46 AWWs for each group - Total 92 per group). The attrition was largely due to the unavailability of the CHWs on the days of test and evaluation due to emergency visits. The demographic details of the participants are given in Table **??**.

Participation in the playtesting activity was voluntary, with an option to quit anytime during the research. CHWs 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.

4.1.2 Instrumentation

4.1.2.1 Core Knowledge Questionnaire

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. This questionnaire was initially prepared in English and then auto-translated to Indian languages by Google translation services followed by human corrections. Initially, it was translated to Hindi, Marathi, and Bengali as most of the respondents' mother tongue majorly comprised of these languages.

4.1.2.2 Game Experience Questionnaire

We tried to conduct the game experience survey through the GEQ (Game Experience Questionnaire) (Ijsselsteijn et al., 2013). The questionnaire contains 33 questions assessing the experience of gaming on seven components: Immersion, Flow, Competence, Positive and Negative Affect, Tension, and Challenge. There are approximately 5 questions per item to make it a robust experience measure. The questions generally try to capture the feelings that they expe-

rienced while gaming. The answers are on 5 points Likert scale which ranges from "not at all" at the low to "extremely" at the higher end. The GEQ is currently available in global Western languages like English, Dutch, Finnish, and German (Ijsselsteijn et al., 2008). In this research, an attempt was made to translate it into Indian languages. We started with Marathi and Hindi as the respondents were majorly into these two languages. The translation process of GEQ was similar to the translation process of the main evaluation questionnaire. Firstly we translated the English texts to Marathi with the help of Google Translation service and IndiaTyping service, to get two linguistic variations. Then a human was involved in correcting the questions' translation one by one. As Indian languages are cultural and gender-sensitive, it was considered that the questions were being asked to an elderly lady in a formal or respectful manner. The choice of vocabulary was chosen so that it is appropriate for the rural respondent, thus avoiding urban lingos. For simplicity of understanding English words in Marathi texts were used which are commonly used by local people. A reference to the GEQ and the translation process is in the Appendix Section (Figure : B.4). Later, the GEQ is now in the process of translation into 16 Indian languages: Bengali, Gujarathi, Hindi, Kannada, Malayalam, Marathi, Tamil, Telegu, Odiya, Punjabi, Urdu, Assamese, Nepali, Bhojpuri, Konkani and Maithili. The translated questionnaires are going through rounds of human correction phases.

One of the contributions by the end of this research is the GEQ Analysis Toolkit for analyzing qualitative GEQ feedback. When a user inputs the 33 questionnaire survey results, conducted physically or digitally in the field, converted into a CSV format, an analysis gets conducted through algorithms coded in Python and generate charts and inferences. The algorithm, firstly fixes the negative questions into inverse values. Then it generates a color-coded correlation matrix between all questions. Then it generates another correlation matrix of the broader themes or seven components.

We decided not to include the social presence module as it checks the involvement of a player socially, like engagement with the in-game characters, and the post-game module checks the fatigue or resentment after the player has not played the game for a long time. These 2 modules were beyond the scope of this research, so were excluded.

4.1.2.3 Data Collection method

A baseline knowledge evaluation was conducted before the intervention. Then 4-5 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.

4.1.3 Experimental Design of Arm3

The study follows a quasi-experimental design (QED) because a true experimental design (TED) would not be possible to conduct in this context. The same location and relatively small sample make it difficult to randomize Harris and et.al. (2006). Thus, QEDs have lower internal validity than TEDs. However, QEDs have higher external validity because the intervention is followed by measurement of the outcome Harris and et.al. (2006). In this QED, the game's design is used to evaluate the benefits of the intervention.

4.1.4 Evaluation of Arm5 (AWW and ASHA Group)

CHWs were evaluated thrice in different phases using pen-and-paper questionnaire surveys. The questionnaire starts with a consent form and space to provide demographic details, followed by 40 single-answer, multiple-choice questions of almost equal weightage. The CHWs are supposed to tick a checkbox against the right answer, indicating their choice of option. [Note: The 3 Page Questionnaire will be in the supplementary materials]

A baseline survey was conducted to check the existing knowledge of the CHWs. Then, the intervention was conducted for the intervention groups. All four groups formed a pair of AWW as a team and ASHA as another team (2X2 team formation - Total 4 players) for every round. IG1 was conducted through card games on their smartphones. IG2 was conducted through a physical or paper card deck. IG3 has imparted the same knowledge through in-person classroom training. Similar surveys were conducted for CG, but no training was provided to

check for placebo effects.

After the intervention or three rounds of gameplay, a post-test was conducted to check the knowledge gains of the CHWs. We should consider that there might be a potential novelty effect or the chances of being effective when initially adopted but fade with time. Therefore, it becomes crucial to understand the long-term effects of the intervention on learning through longitudinal research. After three weeks, a delayed retention test (DRT), similar to the post-test, was performed for all players. According to previous literature Haynie (1994); Nungester and Duchastel (1982) on DRT, a 3-week delay length (more than or equal to 2) was chosen to represent a typical span for DRT. Players were not briefed or previously informed about conducting DRT. CG was not trained throughout the study. Later, after the study, CG was also trained to match the benefits of IGs and bridge the knowledge gap.

4.1.5 Ethics Declaration

All study procedures were approved by the IIT Bombay Institutional Review Board (IRB) (Proposal Number: IITB-IRB/2022/051) and the IRB approval is attached in the Appendix (Figure : I.1) . All participants provided informed consent prior to data collection. All methods were carried out in accordance with relevant guidelines and regulations set by the Institute Ethics Committee which strictly adheres to the Declaration of Helsinki (World Medical Association, 2013) developed by the World Medical Association.

Chapter 5

Results and Discussions

5.0.1 Analysis and Results

5.0.1.1 Arm 1 Study: Burhanpur - ASHA Workers for physical card version

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, the 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 groups. 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.

In order to check if there was a significant difference between scores, 1 sample paired t-test between the scores was conducted. 3 groups were paired in combination with 2 and tested for significant differences. 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 the 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 a significant difference between the two post-tests (immediately after the intervention and a week after the intervention), but the p-value was less signifying a marginal loss of knowledge due to refreshing knowledge by playing with the cards throughout the week. The mean difference between the 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) patterns found between factors like age, years of formal education, experience as an ASHA, and the scores obtained in each test or the delta learning between intervention phases.

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

5.0.1.2 Arm 3 Study: Mumbai - Nursing Students

The first-year ANM batch (n=39, Average Age=19 years, SD=2.28) had recently joined the course in the last 2 months. They didn't have any prior knowledge about immunization. They mostly did guesswork filling out the pretest questionnaire. Conducting t-tests we found no significant difference between the pre and post-test of the physical card group [p=0.197 almost 0.2, average improvement in scores = 4.6] but was significant in the digital group [p=0.0009,

average improvement in scores = 16.5]. As the intent of this research is to study the effectiveness of the tool, particularly as a refresher training, this cohort does not match well with the requirements. However, we see promising improvements in results in the digital group.

The second-year ANM batch (n=29, Average Age=20.25 years, SD=2.25) had been taught immunization as coursework. There was a significant difference in both the physical card group [n=19, p=0.003, average improvement in scores = 3.63, SD=4.7] and the digital app group [n=10, p=0.002, average improvement in scores = 8.5, SD=6.4]. The digital app group performed better but there was a large variation in the scores. So a t-test between the differences in the card and digital app groups was performed. It shows that the differences are not significant (p=0.051). Though there is a significant improvement in scores from pre to post-test for both groups, we cannot conclude that both interventions had a significant difference between them.

The First and Second-year BSc Nursing batches were excluded from the study calculations as they were not taught immunization in their coursework yet. 4th Year batches were recruited in clinical practices in hospitals, so were not reachable. So we decided to conduct the study only on the 3rd Year BSc Nursing batch (n=35, Average Age=20.94 years, SD=1.14) who had been taught immunization in the coursework. There was a significant difference in pre and post-tests within the groups for both the physical card group [n=25, p=0.0000007, average improvement in scores = 9.16, SD=6.88] and the digital app group [n=10, p=0.00005, average improvement in scores = 12.3, SD=5.38]. The digital app group performed better but there was a large variation in the scores. So a t-test between the differences in the card and digital app groups was performed. It shows that the differences are not significant (p=0.17). Though there is a significant improvement in scores for both groups, we cannot conclude that both interventions had a significant difference between them and ineffective refresher training. The findings are visualized using box plots shown in Figure E.7 in the Appendix section.

The GEQ was first tested on this cohort, 3rd Year BSc Nursing batch. The questions were analyzed and represented in a correlation matrix shown in Figure E.8 in the Appendix section.

5.0.1.3 Arm 4 Study: Burhanpur - ASHA Workers for digital or Android version

The second phase of the study with the digital game app was conducted in Burhanpur with a different sample (n=30).

	Intervention Group-1 (IG-1) Digital Card Game		Intervention Group-2 (IG-2) Physical Card Game		Intervention Group-3 (IG-3) Classroom training	
Test phase	Mean (SD)	Median (min-max)	Mean (SD)	Median (min-max)	Mean (SD)	Median (min-max)
Pre-test	25.80 (4.81)	26 (15-36)	24.35 (5.02)	24 (16-35)	25.35 (4.30)	25 (15-34)
Post-test	33.83 (4.03)	34 (25-40)	32.12 (4.36)	32 (21-40)	28.05 (3.73)	28 (19-36)
Late Post-test (After 3 weeks)	30.55 (4.04)	31 (23-39)	30.43 (4.20)	30 (23-39)	26.25 (3.32)	26 (19-33)

Table 5.1: Test Scores

5.0.1.4 Arm 5 Study: Findings from AWW-ASHA group study

Table 5.1 tabulates the scores for 3 phases of the tests for the four groups. After testing assumptions for t-tests like normality and sphericity for all four group scores, Pairwise t-tests were performed to check within-group and between-group differences at every phase of the evaluation. Repeated Measure ANOVA (RM-ANOVA) was also performed to confirm whether an overall difference in scores was found in each phase of the evaluation.

IG-1 and IG-2, or both Card Game groups, performed significantly better than IG3 (Classroom group) and CG(Control Group) ($p<0.05$), showing the effectiveness of teaching through card games. Though the IG1 or digital games group scored more than the IG2 or physical game group, significant differences were not observed between IG1 and IG2 ($p>0.05$), signifying a marginal difference in effectiveness between the two gameplay modes. The CG or control group performed significantly worse than all other groups, nullifying the placebo effects ($p<0.05$). This confirms the RQ2. The long post-test scores for IG1 and IG2 were almost similar, showing a decline in post-test scores. The Control group also showed similar trends. This signifies that the knowledge refresher efforts fade without reinforcement learning.

5.0.2 Discussion

In summary, the playful activity with immunization cards was found to be significantly effective for refresher training of ASHAs with significant knowledge retention. The results were compared by repeating the experiment with both groups. The digital card mode was found to be significantly better in most cases except in a few.

There is a subtle trend that shows that with growing age the delta change in knowledge gains between pre and post-test was getting lower. However, in this research, the trend was not found significant with a 95% confidence interval. Research on learning in other contexts also finds similar results. Years of formal education also have an insignificant effect on baseline score, as the knowledge or experience gained mostly depends on the years of experience, working in the field as an ASHA worker, and having hands-on experience dealing with common issues. As a large number of ASHAs were in the category of 9-10 or 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 mismatches regarding the standardization of information were 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 the 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 creating 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 was randomized to minimize the question's positional effect and order remembrance. 3 sets of questionnaires were made for each language with a randomized order of questions.

Some ASHAs, especially the ones with low formal education, faced difficulty with reading Hindi numbers printed on the cards as well as while filling out the survey questionnaire. In the next phase, the numbers were changed to English and the words in Hindi were unchanged.

There were some ASHAs who studied in a Madrasa and could only recognize English and Urdu numbers. They required translation of the numbers in English in order to fill out the form but still managed to play cards as the rest of the information on the card was enough to play. So in the next phase, we changed all numbers in the card and the app to English numbers.

Focused Group Discussions with ASHAs reveal 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, or not practicing standards of hygiene, is often blamed on 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 training, they could help minimize these faults in their daily job to a large extent, thus strengthening 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 in 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 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 as a mother.

5.0.3 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 ASHA refresher training, knowledge gains, and retention.

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

5.0.4 Contributions of the research Study

Our contribution broadly lies in

Literature	The research broadens the literature on effectiveness and impacts of physical and digital games as tools for refresher training healthcare workers from two cadres playing collaboratively.
Tool/Artifact	Designing a deck of cards on the topic of immunization, which can be used as an artifact for building new games out of new playing rules,
Survey Form	Creating a 3-page Questionnaire to evaluate knowledge gained through the gameplay,
Software/Tool	Creating an Android game designed in Unity, hosted as free open access for downloading from Google and Apple PlayStores
Repository	Open Access Unity Project, code and materials for forking/modifying on GitHub.

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 ।

---

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

	A	B	D	E	F	G
1	Sl	English	IndiaTyping	Google	Corrected Human	Reverse Translated
2	1	I felt content	मला समाधान वाटले	मला सामग्री वाटली	मला समाधान वाटलं	I was satisfied
3	2	I felt skillful	मला कुशल वाटले	मला कुशल वाटले	मला खेळामुळे खूप कुशल वाटलं	I felt very skilled because of the game
4	3	I was interested in the game's story	मला खेळाच्या कथेत रस होता	मला खेळाच्या कथेत रस होता	या खेळामधील गोष्टी साठी मी उत्सुक होते	I was looking forward to the things in this game
5	4	I thought it was fun	मला वाटलं गंमत आहे	मला वाटले की ते मजेदार आहे	मला हा खेळ गम्मत वाटली	I had this game of fun
6	5	I was fully occupied with the game	मी खेळात पूर्णपणे गुंतले होते	मी खेळाने पूर्णपणे ताब्यात घेत होतो	मी खेळामध्ये पूर्ण दंग झालेले	I was full of timber in the game
7	6	I felt happy	मला आनंद वाटला	मला आनंद झाला	मला आनंद वाटला	I was happy
8	7	It gave me a bad mood	मला वाईट मूड दिला	यामुळे मला एक वाईट मूड दिला	याच्यामुळे मला वाईट अनुभव आला	I had a bad experience because of this
9	8	I thought about other things	मी इतर गोष्टींचा विचार केला	मी इतर गोष्टींबद्दल विचार केला	मी खेळताना दुसऱ्या गोष्टींचा विचार करता होते	I was thinking of other things while playing
10	9	I found it tiresome	मला ते कंटाळवाणे वाटले	मला ते कंटाळवाणे वाटले	मला हा खेळ थकवणारा वाटला	I found this game tiring
11	10	I felt competent	मला सक्षम वाटले	मला सक्षम वाटले	मला सक्षम असल्यासारख वाटलं	I felt like I was able to
12	11	I thought it was hard	मला वाटले ते कठीण आहे	मला वाटले ते कठीण आहे	मला वाटले ते कठीण आहे	I thought it was hard
13	12	It was aesthetically pleasing	ते सौंदर्यानि सुखावणारे होते	हे सौंदर्यात्मकदृष्ट्या आनंददायक होते	खेळ दिसायला सुंदर आणि आकर्षक होता	The game was pretty and attractive to see
14	13	I forgot everything around me	मी माझ्या आजूबाजूचे सर्व काही विसरलो	मी माझ्या सभोवतालचे सर्व काही विसरलो	मी सगळं विसरून खेळात आकंठ बुडाले	I forgot all about the game
15	14	I felt good	मला बरं वाटलं	मला बरे वाटले	मला छान वाटल	I would like to feel nice
16	15	I was good at it	मी त्यात चांगला होतो	मी त्यात चांगला होतो	मला खेळात गती होती	I had a speed in the game
17	16	I felt bored	मला कंटाळा आला	मला कंटाळा आला	मला कंटाळा आला	I got bored
18	17	I felt successful	मला यशस्वी वाटले	मला यशस्वी वाटले	मला यशस्वी वाटलं	I felt successful
19	18	I felt imaginative	मला कल्पनारम्य वाटले	मला काल्पनिक वाटले	मझ्या कल्पनाशक्ती ला चालना मिळाली	My imagination got a walk
20	19	I felt that I could explore things	मला वाटले की मी गोष्टी शोधू शकतो	मला वाटले की मी गोष्टी शोधू शकतो	मला असा वाटलं कि मी पण गोष्टी शिकू शकते	I think I can learn things but
21	20	I enjoyed it	मला मजा आली	मी त्याचा आनंद घेतला	मी इंजॉय केला	I did the engoy
22	21	I was fast at reaching the game's targets	मी खेळाचे लक्ष्य गाठण्यात जलद होते	मी खेळाच्या लक्ष्यात पोहोचण्यात वेगवान होतो	मी खूप वेगाने एक की टप्पा पार करत होते	I was crossing a key phase very fast
23	22	I felt annoyed	मला चीड वाटली	मला राग आला	मला खूप त्रासदायक वाटलं	I feel very annoying
24	23	I felt pressured	मला दडपण जाणवले	मला दबाव वाटला	मला दबाव जाणवला	I felt the pressure
25	24	I felt irritable	मला चिडचिड वाटली	मला चिडचिडे वाटले	खेळताना माझी चिडचिड झाली	I got irritated while playing
26	25	I lost track of time	मी वेळेचा मागोवा गमावला	मी वेळेचा मागोवा गमावला	मी खेळताना वेळेचा भान विसरले	I forgot about the idea of time while playing
27	26	I felt challenged	मला आव्हान वाटले	मला आव्हान वाटले	मला खेळ आव्हानात्मक वाटला	I found the game challenging
28	27	I found it impressive	मला ते प्रभावी वाटले	मला ते प्रभावी वाटले	मला खेळ आकर्षक वाटला	I found the game attractive
29	28	I was deeply concentrated in the game	मी खेळात मनापासून एकाग्र होतो	मी गेममध्ये खोलवर लक्ष केंद्रित केले होते	मी खेळ खेळताना खूप एकाग्र झालेले	I
30	29	I felt frustrated	मला निराश वाटले	मी निराश झालो	मला खूप निराश वाटले	I felt very frustrated
31	30	It felt like a rich experience	एक समृद्ध अनुभव वाटला	हा एक समृद्ध अनुभव वाटला	हा खूप आल्हाददायक अनुभव होता	It was a very pleasant experience
32	31	I lost connection with the outside world	माझा बाहेरच्या जगाशी संपर्क तुटला	मी बाह्य जगाशी संबंध गमावला	मी बाकीच्या जगाचा भान विसरले	I forgot about the rest of the world
33	32	I felt time pressure	मला वेळेचा दबाव जाणवला	मला वेळ दबाव वाटला	मला वेळेत पूर्ण करण्याचा दबाव जाणवला	I felt the pressure to complete in time
34	33	I had to put a lot of effort into it	त्यासाठी मला खूप मेहनत घ्यावी लागली	मला त्यात बरेच प्रयत्न करावे लागले	मला खूप मेहनत घ्यावी लागली	I had to work a lot of hard work
35						
36	34	not at all	अजिबात नाही	अजिबात नाही	अजिबात नाही	Not at all
37	35	slightly	किंचित	किंचित	किंचित प्रमाणात	Quantitatively
38	36	moderately	माफक प्रमाणात	माफक प्रमाणात	मध्यम प्रमाणात	To a moderate amount
39	37	fairly	प्रामाणिकपणे	प्रामाणिकपणे	चांगल्या प्रमाणात	Well
40	38	extremely	अत्यंत	अत्यंत	खूप जास्त	Too much

Figure B.4: GEQ Translation Processs

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)

Table C.2: Participants' Demography

	Intervention Group-1 Digital Card Game		Intervention Group-2 Physical Card Game		Intervention Group-3 Classroom training		Control Group No training	
Parameters	ASHAs(%)	AWWs(%)	ASHAs(%)	AWWs(%))	ASHAs(%)	AWWs(%)	ASHAs(%)	AWWs(%)
Age								
Less than 30	2(4.35%)	1(2.17%)	2(4.35%)	2(4.35%)	1(2.17%)	1(2.17%)	2(4.35%)	1(2.17%)
30-40	24(52.17%)	22(47.83%)	25(54.35%)	20(43.48%)	24(52.17%)	21(45.65%)	24(52.17%)	20(43.48%)
40-50	19(41.3%)	22(47.83%)	18(39.13%)	23(50%)	20(43.48%)	23(50%)	18(39.13%)	24(52.17%)
No information	1(2.17%)	1(2.17%)	1(2.17%)	1(2.17%)	1(2.17%)	1(2.17%)	2(4.35%)	1(2.17%)
Education (grade)								
$Below 8^{th}$	2(4.35%)	2(4.35%)	2(4.35%)	2(4.35%)	2(4.35%)	3(6.52%)	2(4.35%)	2(4.35%)
$8^{th} - 10^{th}$	10(21.74%)	15(32.61%)	10(21.74%)	12(26.09%)	9(19.57%)	11(23.91%)	8(17.39%)	13(28.26%)
$10^{th} - 12^{th}$	30(65.22%)	24(52.17%)	29(63.04%)	28(60.87%)	30(65.22%)	28(60.87%)	31(67.39%)	27(58.7%)
Graduate and above	3(6.52%)	4(8.7%)	4(8.7%)	3(6.52%)	4(8.7%)	3(6.52%)	4(8.7%)	3(6.52%)
No information	1(2.17%)	1(2.17%)	1(2.17%)	1(2.17%)	1(2.17%)	1(2.17%)	1(2.17%)	1(2.17%)
Experience as CHWs (years)								
0-5	5(10.87%)	4(8.7%)	4(8.7%)	4(8.7%)	4(8.7%)	3(6.52%)	4(8.7%)	4(8.7%)
5-10	19(41.3%)	16(34.78%)	20(43.48%)	16(34.78%)	19(41.3%)	16(34.78%)	17(36.96%)	17(36.96%)
10-15	17(36.96%)	19(41.3%)	16(34.78%)	18(39.13%)	16(34.78%)	19(41.3%)	19(41.3%)	18(39.13%)
Above 15	4(8.7%)	5(10.87%)	5(10.87%)	7(15.22%)	5(10.87%)	7(15.22%)	5(10.87%)	6(13.04%)
No information	1(2.17%)	2(4.35%)	1(2.17%)	1(2.17%)	2(4.35%)	1(2.17%)	1(2.17%)	1(2.17%)

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

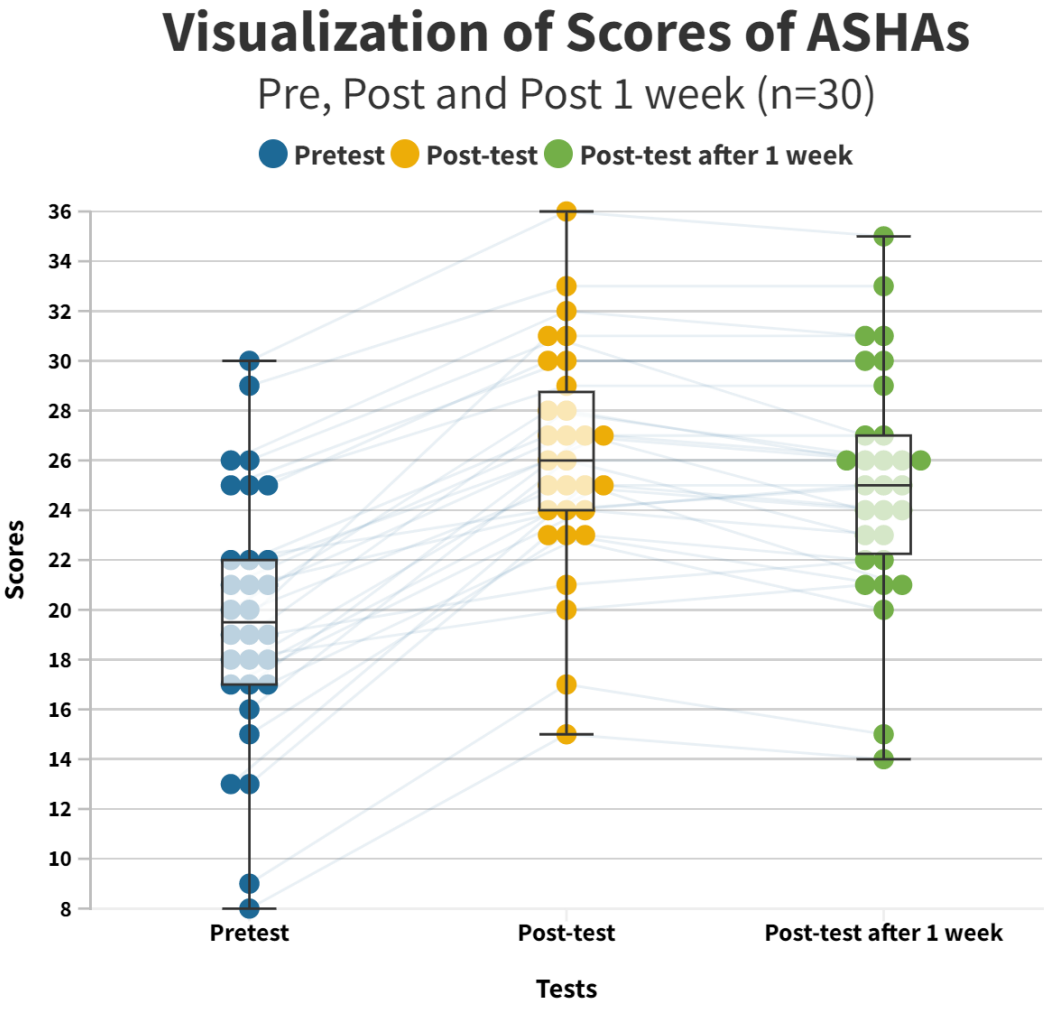
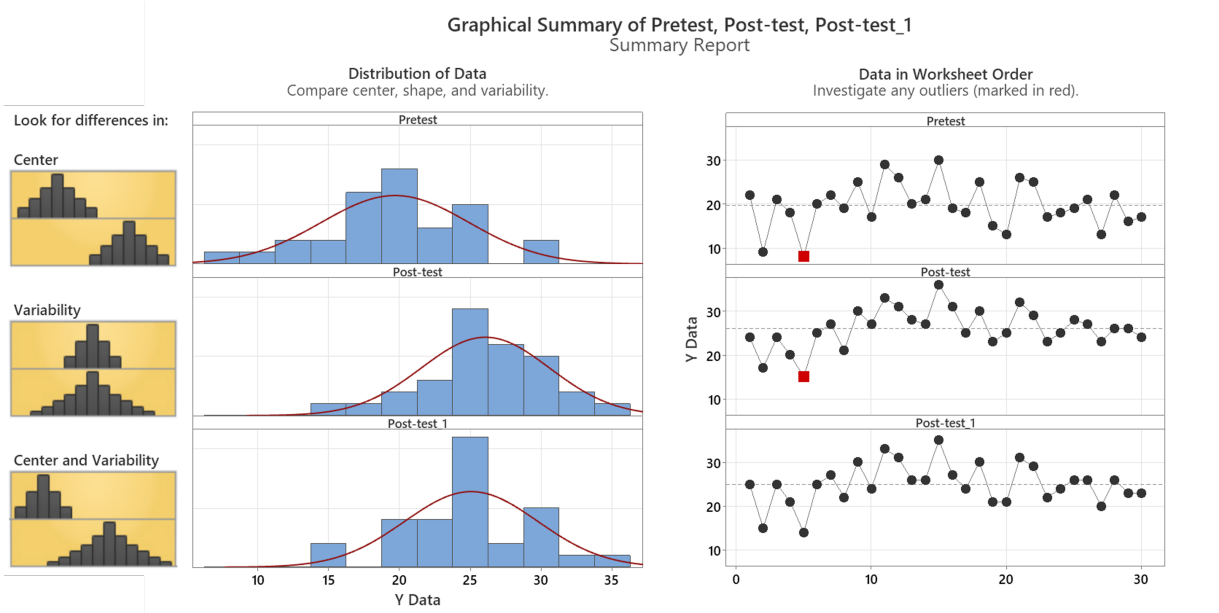


Figure D.1: Comparison of Pre-test, Post-test, and Post-test (after one week) scores



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

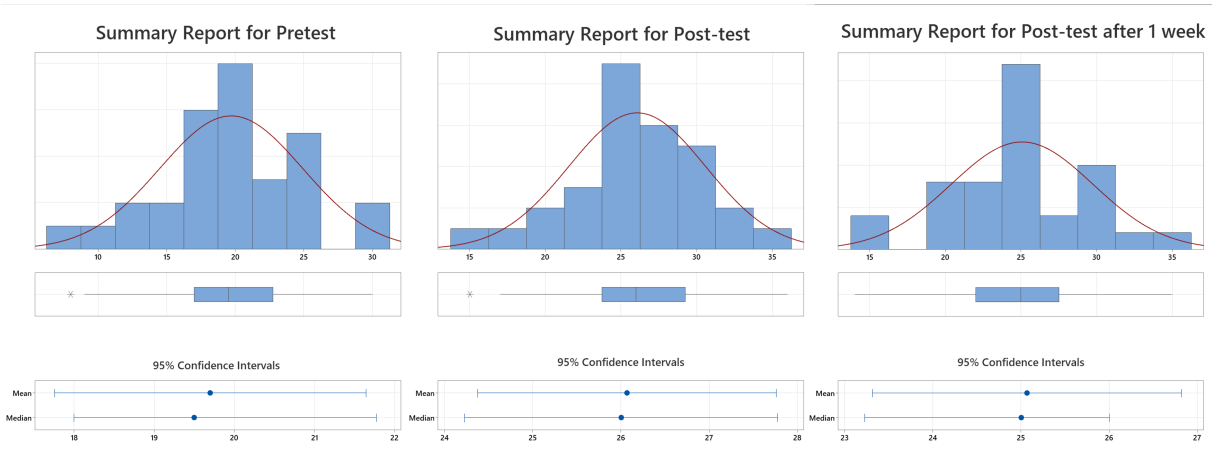


Figure E.1: Comparison of distributions between Pre-test, Post-test, and Post-test (after one week) scores

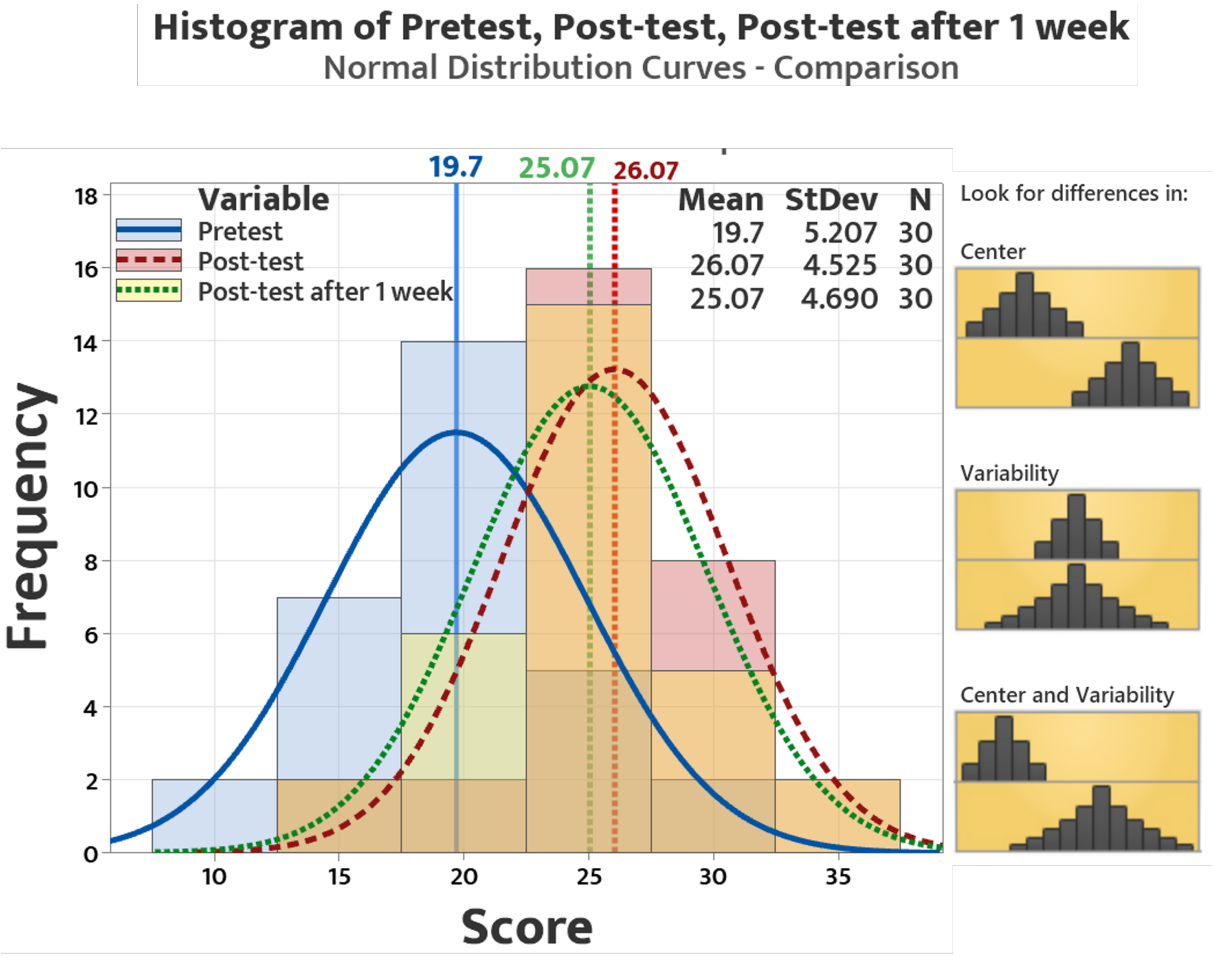


Figure E.2: Combination of above 3 histograms

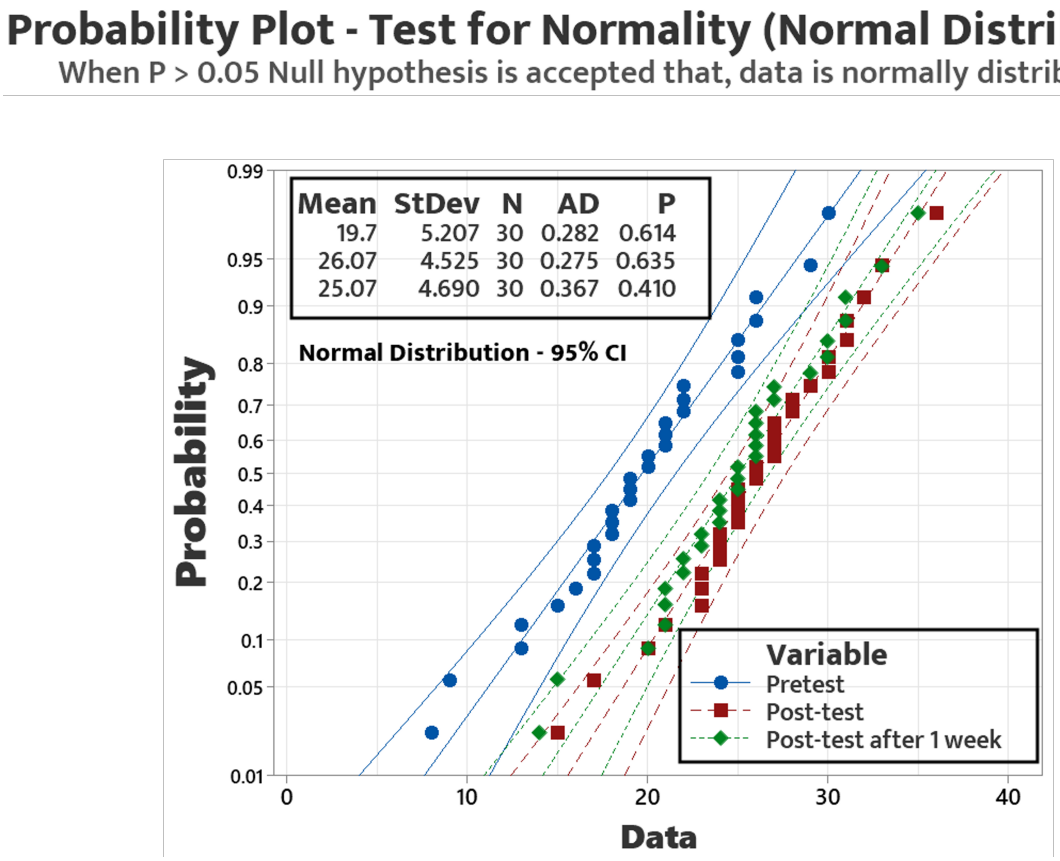


Figure E.3: Comparison of normality or Normal Distribution using Anderson Darling Test between Pre-test, Post-test, and Post-test (after one week) scores

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

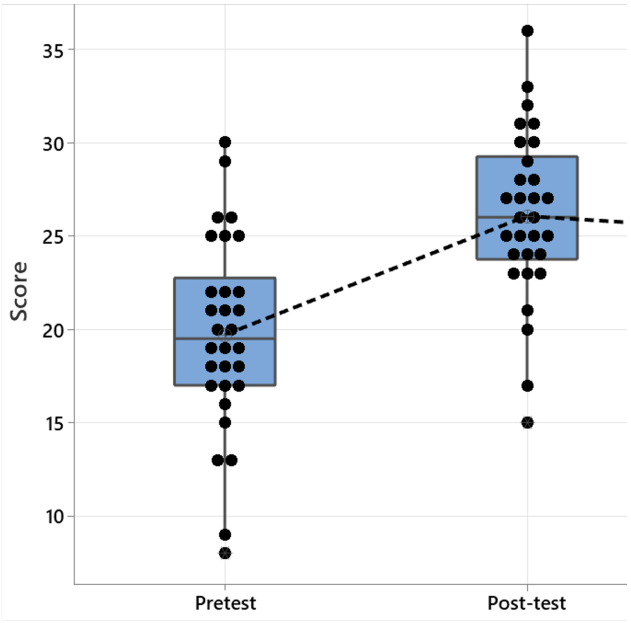


Figure E.5: Results from Paired T-tests between Pre-test, Post-test scores

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

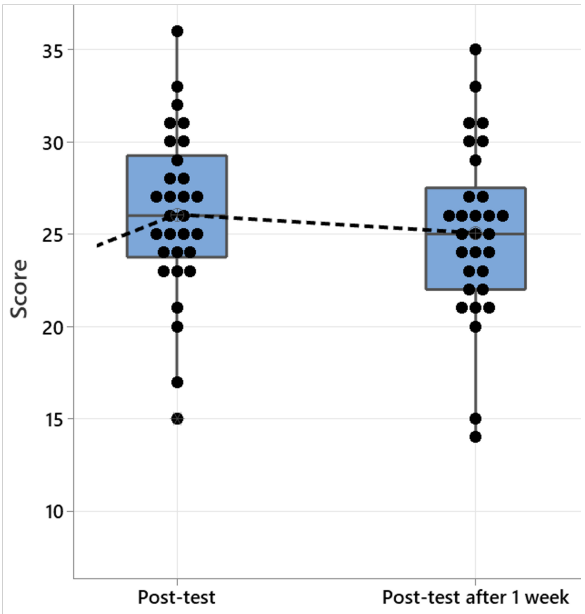


Figure E.6: Results from Paired T-tests between Post-test, and Post-test (after one week) scores

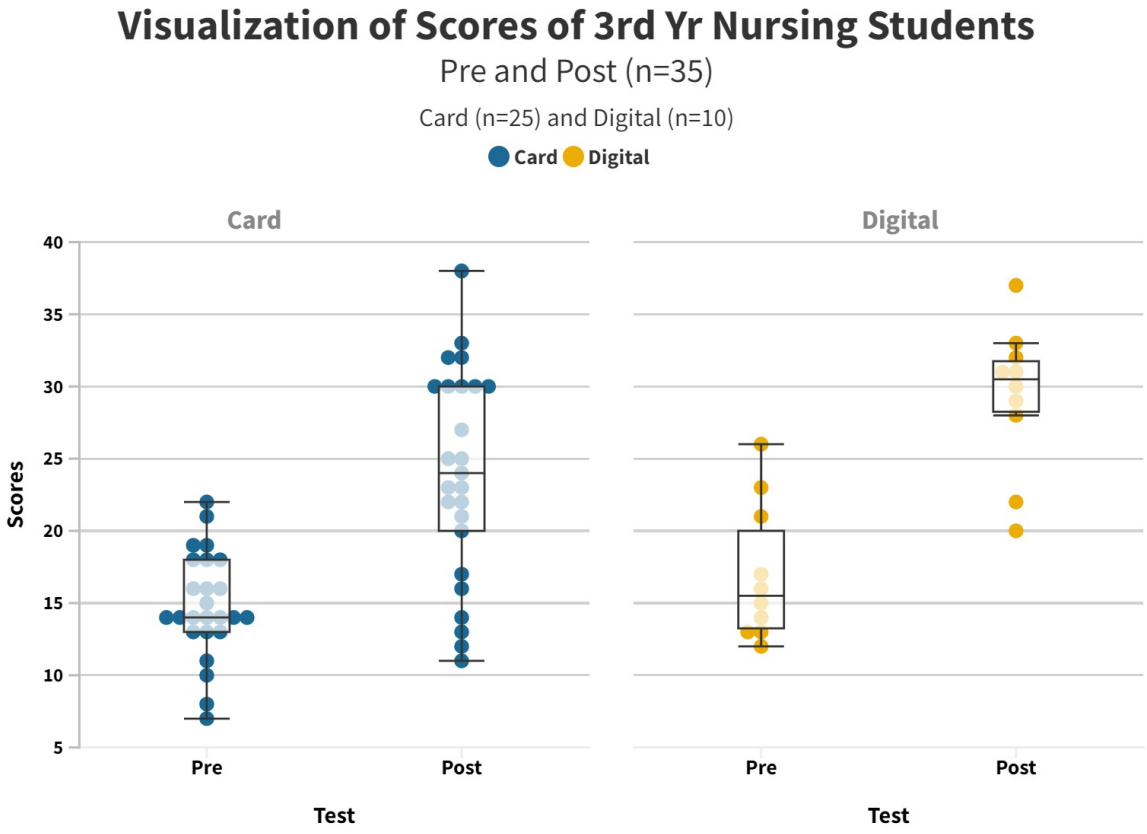


Figure E.7: Results from comparing the scores of nursing students

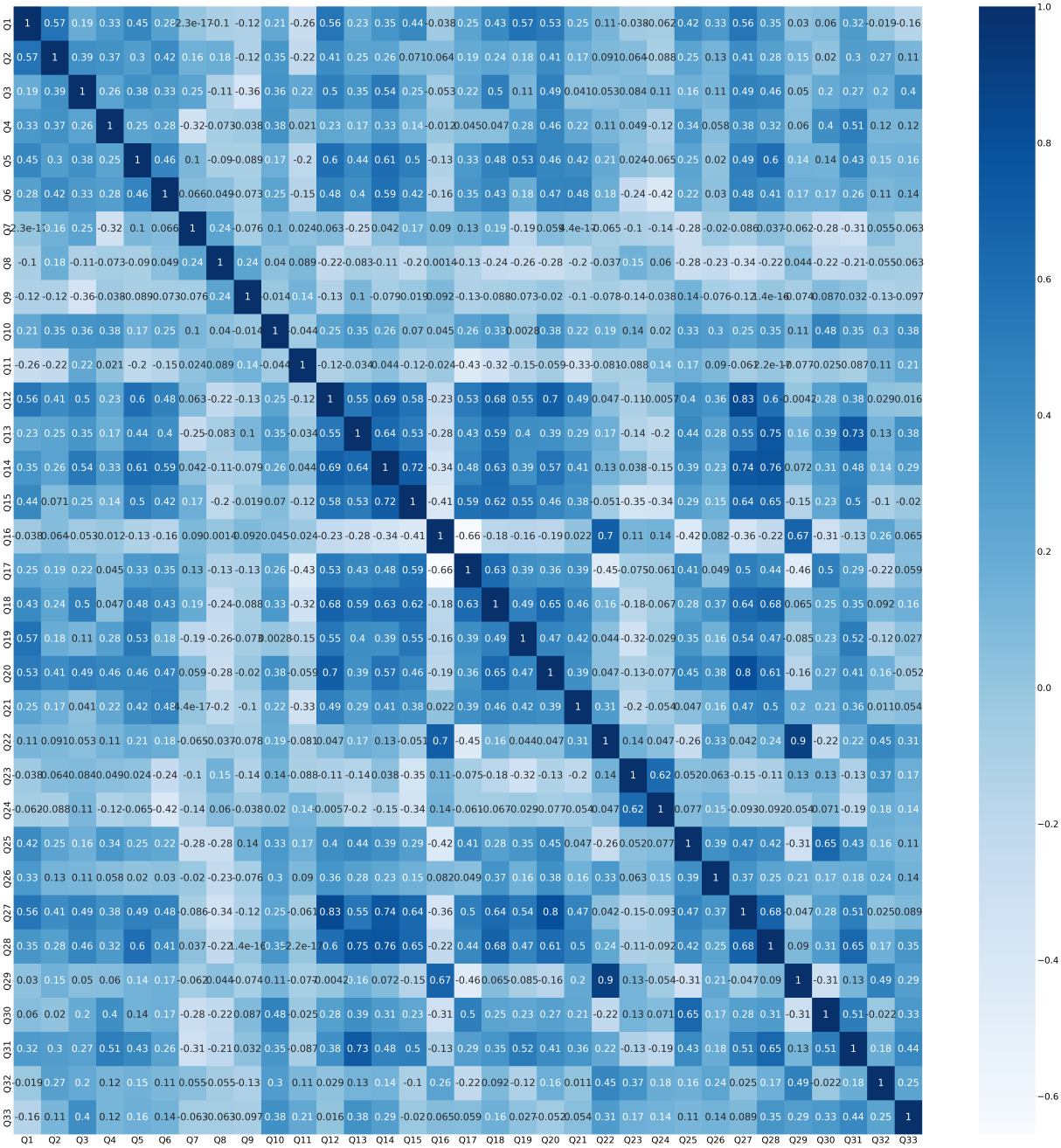


Figure E.8: Correltion matrix of GEQ of nursing students cohort

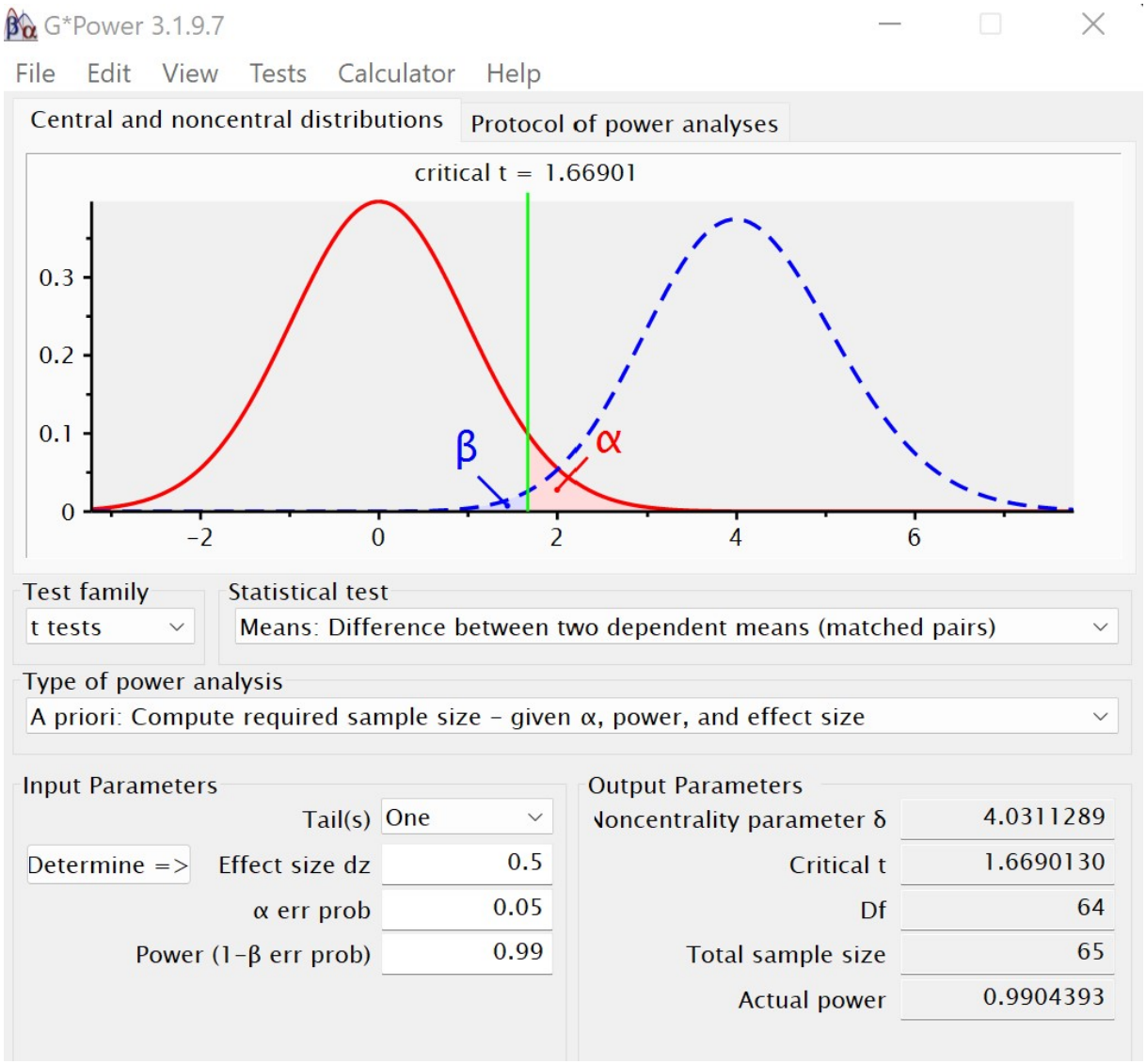


Figure E.9: Sample calculation for paired t-test, given alpha, power and effect size

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)

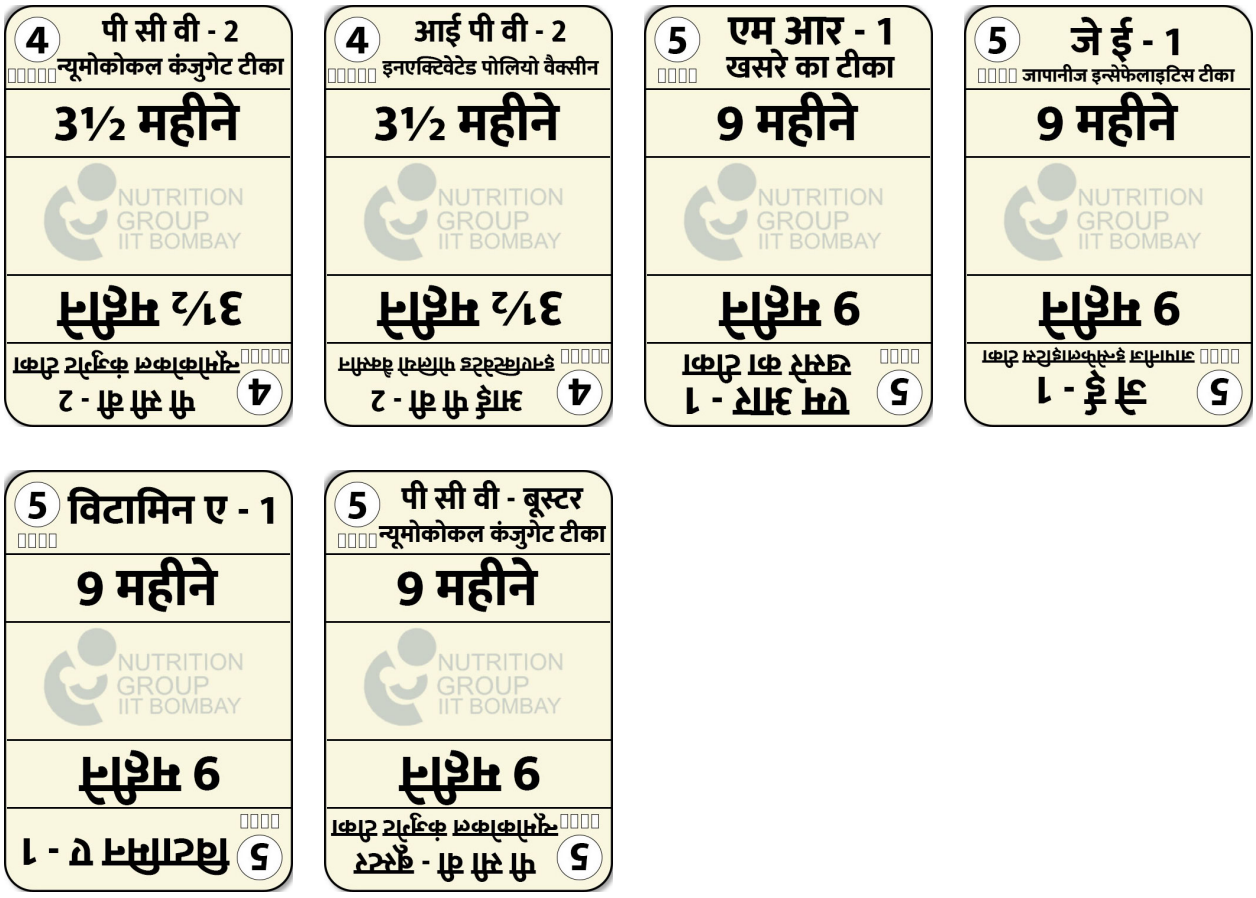


Figure G.2: Immunization cards for children below 1 year (continued from previous page)

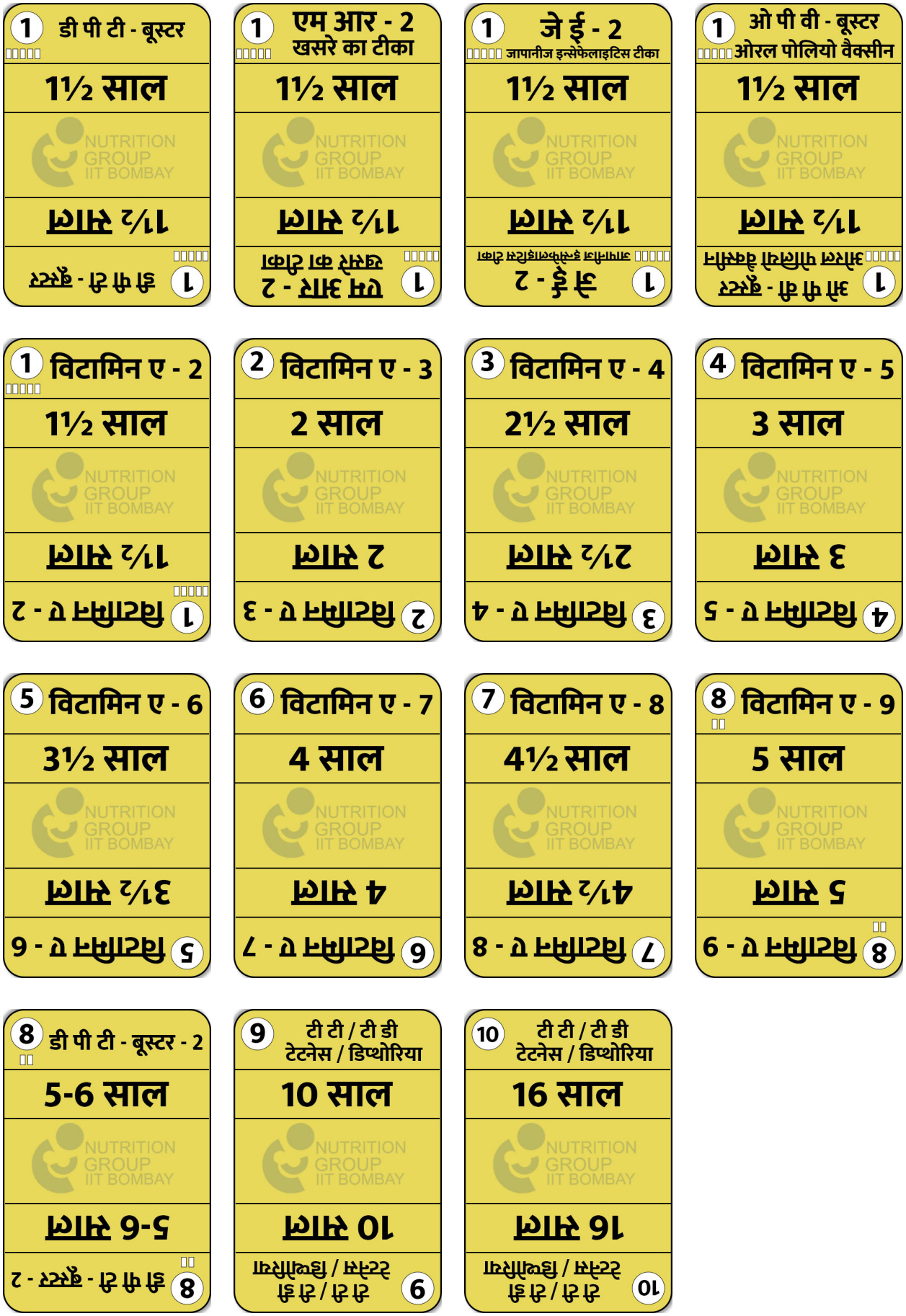


Figure G.3: Immunization cards for children above 1 year

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

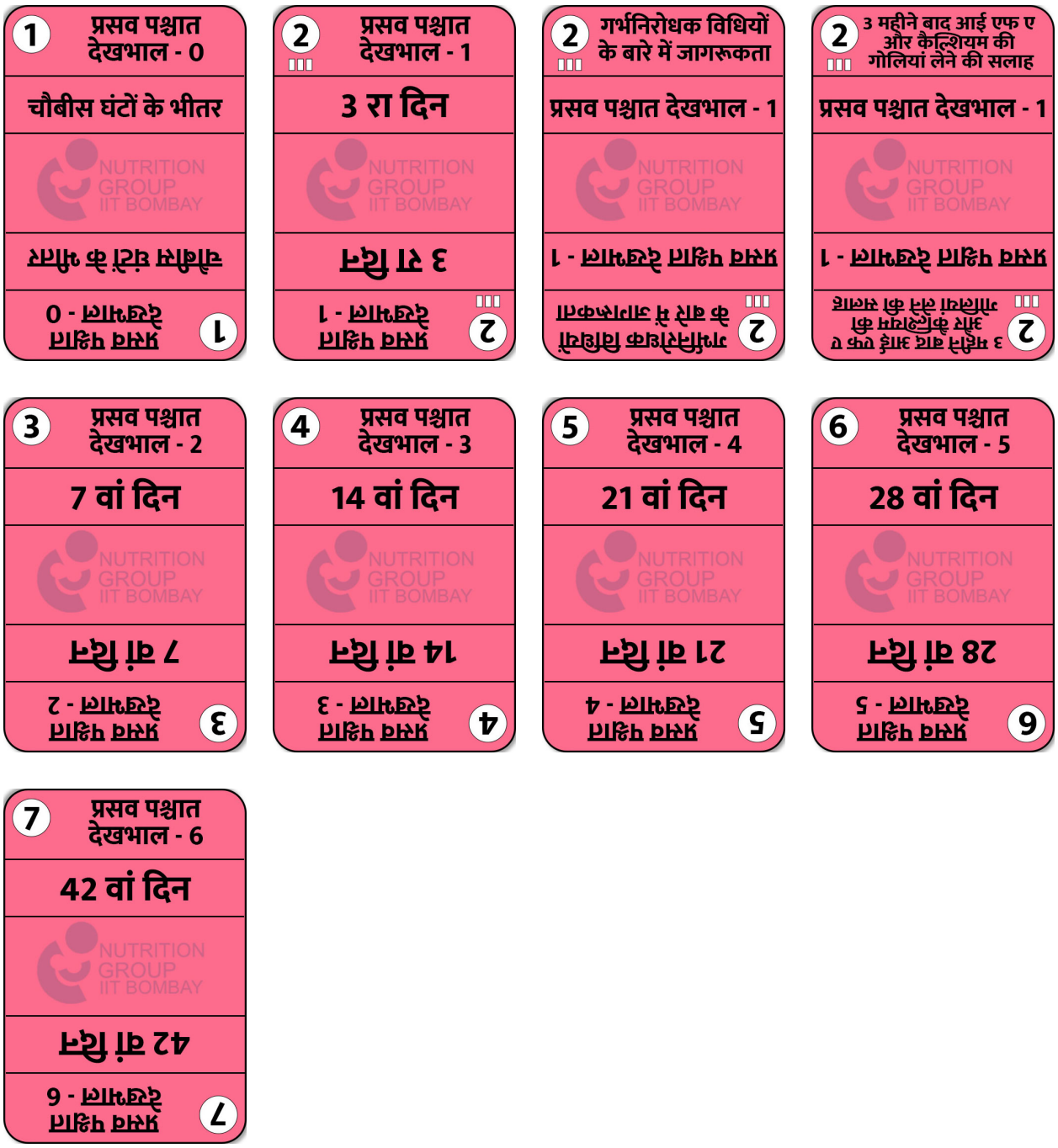


Figure G.5: Post-Natal-Care (PNC)

Appendix H

Mobile app Screenshots

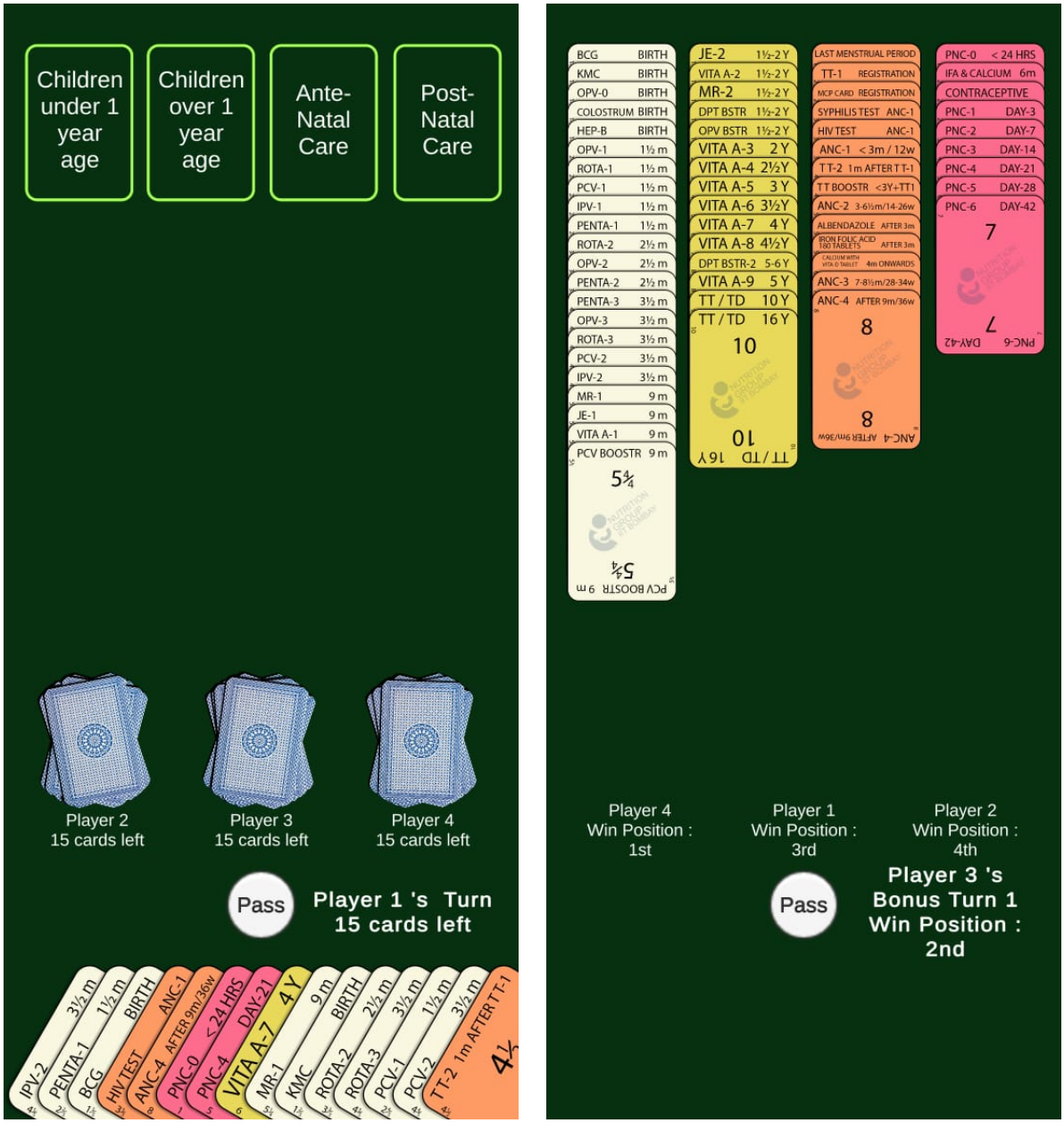


Figure H.1: Mobile app Screenshot - Play Start and End Screen (4 players playing with one phone and passing after their turn)

Appendix I

Institute Review Board Approval

IRCC, Office of the Dean R&D, IIT Bombay

INDIAN INSTITUTE OF TECHNOLOGY BOMBAY

Institutional Review Board (IRB)

January 17, 2023

To
Prof. Satish Agnihotri
CTARA
IIT Bombay

Ref: Proposal No. IITB-IRB/2022/051

Sub: Review of the above-mentioned project proposal

Dear Professor,

Thank you for submitting your proposal to the IITB Institutional Review Board (IRB) for review. The IRB has reviewed the proposal submitted by you and the following proposal is approved:

Proposal number : **IITB-IRB/2022/051**
Title : **Refresher Training through Games for Frontline Healthcare Workers on Maternal and Newborn care**

The IRB approval is for the ethical conduct of the study. The study is approved for the entire duration and a closure report should be submitted within 2 months of the completion of the study.

Further, it is also confirmed that neither you, nor any of the study team members have participated in the decision-making process of the committee.

In case there are any changes in the proposed work (which is not limited to scope, dates, participants and methodology etc.), please communicate to IRB within 15 days of such a change.

Thank you.
With Best wishes from IRB for your study,

D Parthasarathy
Chairperson IITB-IRB

Figure I.1: IRB Approval

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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* (Best Paper award in Long Paper category)
   https://dl.acm.org/doi/10.1145/3429360.3468186

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* (Best Paper and Best Presentation award in Long Paper category)
   https://dl.acm.org/doi/10.1145/3516492.3558788

3. **Majhi, A.**, Agnihotri, S. B., Mondal, A., 2021. Replay, Revise, and Refresh: Smartphone-Based Refresher Training for Community Healthcare Workers in India ", *HCI International 2024*
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4. **Majhi, A.**, Agnihotri, S. B., Mondal, A., 2024. Mapping Child Malnutrition and Measuring Efficiency of Community Healthcare Workers through Location Based Games in India. International Conference on Information Technology for Social Good (GoodIT '24)
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5. **Majhi, A.**, Agnihotri, S. B., Mondal, A., 2024. Refresher Training through Digital and Physical, Card-BasedbGame for Accredited Social Health Activists (ASHAs) and Anganwadi Workers (AWWs) in India. CHI PLAY Companion '24, October 14–17, 2024, Tampere, Finland
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