Co-Ideating with Caregivers and Healthcare Professionals: Socio-Technical Strategies to Support Early Childhood Nutrition

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Malnutrition is a major public health concern that threatens the lives of millions of children around the world. Caregivers and healthcare professionals play a crucial role in shaping healthy eating habits for infants and young children (IYC). Taking a socio-technical approach, this study explores the perspectives, ideas and strategies of caregivers and healthcare professionals to address IYC nutrition challenges in two low-resource communities in Peru. Following a co-design approach, we conducted four co-ideation workshops with separate sessions for caregivers and healthcare professionals. Using different materials, participants collaboratively co-created different ideation boards that supported the idea generation process and discussion among participants. The co-created ideation boards show a number of socio-technical strategies to promote and support healthy complementary feeding practices and enhance caregivers' and IYC experiences at the healthcare centre highlighting the situated elements of caring ecologies. Based on our findings, we present a number of implications for socio-technical design to support early childhood nutrition and promote healthy feeding practices in low-resource settings.

CCS Concepts: • **Human-centered computing → Empirical studies in HCI**.

Additional Key Words and Phrases: Complementary Feeding, Childhood Nutrition, Socio-Technical Strategies, Co-ideation

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1 Introduction

Malnutrition is a major public health issue [163] that affects millions of children around the world [4, 136]. In 2020, the World Health Organisation (WHO) estimated that 45% of deaths of children under five were related to preventable nutritional factors [134]. Poor quality diets in infants and young children (IYC), unhealthy food environments, lack of access and low engagement with health care services, and inadequate nutritional counselling are major factors contributing to malnutrition, especially in low- and middle-income countries (LMICs) [15, 37, 131, 180]. The coexistence of undernutrition and overnutrition, also called the double burden of malnutrition (DBM), is particularly affecting children in LMICs [163, 197]. After the sixth month of life, breast milk or milk formula are not enough to meet the nutritional requirements of IYC, and the introduction of complementary foods is needed, especially between the ages of 6-23 months (the complementary feeding period) [56, 135], the crucial time when malnutrition begins [176]. However, many children are poorly fed, as shown by the global prevalence (45.7%) of zero vegetable or fruit consumption among children aged 6-23 months. In particular, Latin American countries are facing the DBM [64] more than other regions of the world, due to a rapid transition from a predominantly underweight to an overweight population, especially in low-income communities [83]. In Peru, there is an increasing prevalence of obesity and overweight in mothers and children under 5 years [33, 149, 179], and 40% of children aged 6-35 months are anaemic [33], especially from low-income households [43]. Despite efforts of the Peruvian government to address nutritional challenges in IYC through interventions, assistance programmes, and policies (e.g., provision of iron supplementation, micronutrient powders, complementary food, and counselling) [33, 34, 90], they have mainly targeted undernutrition. The limited resources and infrastructure within the Peruvian health system and lack of sustainable funding [90, 169] has impacted the implementation of nutrition policies and food assistance programmes [33, 34, 90]. Thus, early childhood interventions are needed to address different forms of malnutrition beyond single nutritional outcomes [78] to promote and support healthy eating and avoid malnutrition, especially in low-resource settings in LMICs.

Previous research has used technologies to help improve IYC nutrition and health. Examples include technologies for tracking infant feeding, promoting weight control, monitoring children's growth, and providing information on infant feeding and nutrition to enhance parent's nutritional knowledge [35, 60, 82, 177, 183, 200]. However, most technologies have been designed for developed countries, mainly aimed at mothers (as primary caregiver) or a particular condition (anaemia or obesity/overweight), and might not be suitable for low-income communities, and even less so for the Global South [183, 187]. Designing technology in the Global South requires a socio-technical approach [47, 152] that *"consider the human, social, and organisational factors as well as technical"* [14] and environmental (e.g., poor electricity, lack of transport, crime) factors [23, 24, 104]. Thus, the socio-technical context matters and top-down solutions would not work [130], especially in the Global South [9, 23, 24], due to the lack of alignment with community needs and the situated context [160, 183] as community perspectives are often excluded from design [39, 183]. Childhood malnutrition requires collective action and socio-technical interventions with active involvement of community stakeholders (healthcare professionals, caregivers) [183] and an in-depth understanding of the situated context and how the socio-material and spatial practices in early childhood environments influence and shape IYC nutrition [155, 156, 171]. Although,

community-based initiatives have shown some potential to address childhood malnutrition [6, 22, 181], their use in healthcare and technology design is limited in the Global South [87, 183], especially in Latin America [20, 30, 106].

Leveraging previous co-design work in low-resource settings [38] and in the context of maternal and child health in the Global South [39, 182, 184, 194], we further explore communities' perspectives and ideas to promote and support IYC nutrition. We engaged with caregivers of IYC (aged 6-23 months) and healthcare professionals through idea generation workshops in two low-resource communities in Peru. Taking a socio-material lens [38], co-ideation workshops helped identify the ways in which caregivers and healthcare professionals wanted more support to address IYC feeding and nutritional challenges, and proposed strategies for the home, healthcare, and community settings. Our research makes multiple contributions to HCI, CSCW, and healthcare research. We extend previous research understanding childhood nutrition [85] and complex care ecologies [57, 174] by visualising the multiple perspectives of human (e.g., parents, family members, healthcare professionals) and non-human assemblages (e.g., material and spatial elements, including technology) that constitutes the complex care ecologies in IYC nutrition in Peru, highlighting the need for multifaceted and holistic support. This aligns with recent calls to reframe the design space to account for the socio-ecological dynamics (human and non-human) of IYC feeding practices [85, 126] when designing digital health [114, 118]. Second, based on our findings, we present socio-technical design opportunities to support the situated ecologies of care of IYC nutrition across multiple everyday environments. Lastly, our research adds to HCI for Development (HCI4D) research [39, 184, 194] by exploring the design space (using context-relevant design materials) of socio-technical strategies for IYC health in Peru, that has received limited attention.

2 Related Work

2.1 Challenges in Infant and Young Child Nutrition

Childhood malnutrition is a complex public health issue that is influenced by a variety of multiple ecological factors at the individual, interpersonal, environmental, and societal level (e.g., family income, nutritional knowledge, cultural traditions, agricultural practices, food availability within and outside households, food marketing, urbanization, policies, global food systems, etc.) [12, 78, 126, 145, 171]. For example, at the individual level, children might have the natural tendency to reject the bitter flavours in some vegetables [45]. At the interpersonal level, the family and the household environment play a crucial role in building healthy eating habits. For example, mothers, as primary caregivers, usually take the responsibility to ensure a nutritious diet [113], shaping the eating preferences and habits of children [126], as they often tend to provide their children with the same food they eat [159] and may or may not adhere to infant feeding guidelines [126]. The father's eating practices also influence the child's diet, as previous research has reported a higher consumption of unhealthy food (e.g., potato chips, takeaway foods, and sweet beverages) especially in father headed single-parent households [156]. Single-father families experience poorer access to health care [109], financial stress and time constraints [100] impacting on parenting responsibilities to monitor and limit children's food intake [102] and children's weight gain [61, 112]. In addition, family caregivers (e.g., grandparents), friends, and healthcare professionals (e.g., doctors, nurses) play a vital role due to the advice they provide to mothers on infant nutrition [17, 126, 170]. At the environment level, the neighbourhood food environment (e.g., food stores) [116, 122], the accessibility and availability of food (e.g., food insecurity) also influence family diets and infant feeding practices [146]. Moreover, the consumption rates of inappropriate complementary foods (e.g., snacks and ultra-processed foods high in fat, added sugar, and salt) and sweetened beverages are increasing [12, 78, 162], especially in children 6-23 months of age in LMICs (74.1% in Nepal [150], 55% in Cambodia [151], 78% in Peru[148]). In particular, the increased marketing of unhealthy foods [78]

with attractive wraps [141] and ready to eat foods [2] influences the decisions of parents and family caregivers on what food to offer to IYC. Indeed, caregivers' lack of awareness on how to identify healthy food is a barrier to providing a healthy diet to children [123]. All of these ecological factors affect children's diets and early life nutrition differently in each sociocultural context [78, 126].

To address IYC nutritional challenges, different strategies (e.g., interventions, assistance programmes, and policies) have been established to achieve adequate nutrient intake. For example, providing financial incentives, food subsidy programmes, iron supplementation, micronutrient powders, information about proper complementary foods, growth monitoring and nutrition counselling in health services [7, 78, 101]. Other strategies include taste and non-taste exposure to familiarise IYC with fruits and vegetables that can be used within and outside the feeding context [129]. In addition, caregivers have implemented some strategies to decrease the exposure of IYC to the marketing of unhealthy food. For example, giving raisins in a manufactured confectionery bag, swapping less healthy foods for something perceived as more nutritious [195]. In LMICs, community nurses provide health education to families about nutrition and child care, conduct home visits to monitor family growth and development, and provide mentoring and counselling to mothers [170]. In Peru, other food assistance programs include community kitchens (social organisations providing low-cost food) and a glass of milk (provides daily portions of milk and other staple foods to children under six years old) [34]. Although daycare programmes provide complementary food, iron supplementation, and training to caregivers [119], the nutritional quality of foods needs to be improved [41]. Moreover, social programmes and policies have focused mainly on undernutrition with difficulties during their implementation due to limited resources and infrastructure [90, 144]. Low awareness of nutritional recommendations in households (e.g., 5 servings of fruit and vegetables) [50], and communication issues during counselling between healthcare professionals and caregivers [161] also impact IYC nutrition.

2.2 Technology for Infant and Young Children's Nutrition

The Internet has become a powerful communication and knowledge dissemination tool [126] that mothers and family caregivers use when looking for information about IYC feeding practices [46, 49, 177]. Leveraging the growing adoption of the Internet worldwide, health interventions are increasingly using technologies such as web-based and mobile applications to help caregivers to track and monitor the child's feeding habits [115], provide complementary feeding guidelines [157], promote weight control and monitor children's growth [60, 177, 200]. As caregivers turn to digital sources of information [115], there are many reliability issues (e.g., poor content, incomplete or incorrect information) as the majority of information on infant feeding is not based on evidence-based resources [35]. An example of addressing misinformation is the Nutripedia project [189]. This includes the Nutripedia website and *"Chatbot app"*, which shares evidence-based information to provide parents with reliable content. Questions not included in the chatbot's database are asynchronously addressed by experts [189].

In addition, a variety of interventions have focused directly on children, taking advantage of more natural interactions with technology by using sensors and everyday objects, especially at home. For example, enhanced trays (with sensors) that provide visual feedback in the form of colourful lights have been used to support self-feeding among young children with cerebral palsy [65]. FunEat is an interactive tableware designed for children aged 5–7 to encourage healthy eating habits and avoid picky eating behaviours [201] by projecting a game where children feed a virtual pet by eating different types of food placed in specific areas of the plate [201]. Furthermore, a connected tableware (integrating a food tray, a spoon, and a cradle) has been used to increase vegetable consumption in children aged 3-6 years old [98]. Although this system was evaluated with three children, there are no details of the design process, and thus, it is not clear if it

involved caregivers and children. Other examples are the Sensing Fork (a sensor-embedded digital fork) and a mobile game (called Hungry Panda), designed to address children's eating problems, such as being a picky eater and/or easily distracted during mealtime [99]. Furthermore, FeastyMaze, a tangible and multi-sensory (including visual, auditory, olfactory, and tactile stimuli) puzzle game for preschoolers aged 4-6 years to improve children's food literacy and eating behaviour (food neophobia and picky eating) [29]. Another example is TangibleTale [193], a system empirically validated in a home setting among children aged 3 to 6 years and their parents, that applies tangible narrative (tangible interfaces with storytelling) to improve children's eating behaviours. Health-e-Eater [154] is a low-cost system that includes a "magic plate" and companion robot to encourage children aged 2-5 years from low-income families to eat healthy food. However, most technologies have been developed in high-income countries, focusing on mothers as the main caregiver, or children over 2 years old (e.g., neophobia or picky eating behaviour), or on a single condition (anaemia or obesity/overweight), and have not involved the community in the design process. As such, they are not suitable for low-income communities, and even less for the Global South [183, 187].

2.3 Co-design Methods and Tools to Support Participation

The cooperative design approach highlights the importance of hands-on exploration by potential end-users [105], in particular through workshops and collaborative prototyping activities [19] to support mutual learning and the articulation of users' voices in design. Participatory Design (PD) recognises the important role of users, non-designers, as experts in their own lived experiences and practices [167]. In contrast to traditional methods that look at what people do and use, there is a strong focus on what people make to express their thoughts, feelings, ideas, dreams, etc. [165]. The participants would then need tools and techniques for probing and priming that can enable creation to make ideas more tangible [3]. Brandt et al. [21] classifies the tools and techniques to support the active participation of non-designers based on their socio-material affordances that can facilitate making tangible things (e.g., 2-D collages), that can support talking and explaining (e.g., drawings, photos, video, storyboards, diaries, design cards), and the ones that can facilitate acting, enacting and playing (e.g., games, props, role play) [3, 166]. These co-produced materials can evoke emotions and meaning-making associations [81], facilitate thinking through making [188], and reflection in action during design ideation [69]. One important design material commonly used in ideation workshops is Post-It notes that play a key role in contextual design [89] as they support brainstorming [96] and function as cognitive externalisations of design ideas [52].

However, understanding, articulating and conveying participants' experiences and ideas during design sessions can be difficult for low-resource communities [76], especially in the Global South [91, 182, 184]. Community power dynamics (e.g., hierarchical structures) [182], mistrust, and power imbalances between researchers, designers, and local community stakeholders with often conflicting perspectives can hinder people's active participation in design [70, 182–184], and even prevent the implementation due to unseen hidden agendas [48]. For example, Gautam et al. [66] highlights participatory tensions between the goals of local communities and the values and goals of community organisations. Language (e.g., non-English speaking communities), time, space, and sociocultural dynamics also influence the execution of co-design activities [137, 178, 182]. As such, it is essential for external researchers to foster co-design readiness by becoming aware of the situated context, respecting existing sociocultural norms and building trust and empathy with local communities [184]. Moreover, design materials and methods must be adapted to each socio-technical and cultural setting [86, 198]. When design materials and methods are not contextualised, there is a risk of impacting people's participation in design as they could be confusing [76], foreign, and difficult to understand [39, 182]. Thus, it is necessary to develop and adapt tools and methods that can help community participants express themselves in

creative ways [167], build their confidence to be ready to participate in co-design [91, 184], value their lived experiences [87, 184], promote individual and collective agency [153], and reflective practices [111].

2.4 Motivating the Use of a Socio-Ecological Approach

As presented above, childhood malnutrition is influenced by multiple ecological factors at different levels. In this context, previous work has emphasised the need to understand IYC feeding practices and childcare nutrition from an ecological perspective [85, 126] using Bronfenbrenner's Ecological Model [25]. This means that any intervention targeting IYC feeding practices needs to understand how these practices are influenced by several factors at the individual, family, community and societal level [126]. For example, Muniandy [126] places both the mothers and the children at the centre as IYC are unable to make their own eating decisions, and describes the microsystem layer around them representing the interaction with immediate people (e.g., family) and settings (e.g., household, neighbourhood) around the mother and child. The second layer is the mesosystem representing interactions or connections between two or more immediate people or settings (microsystems) where the child belongs. The exosystem is the third level representing external people and settings that would indirectly affect the child (e.g., community, mass media). The last level is the macrosystem representing the social and cultural environment that influence maternal decisions around the child and feeding practices [126]. Few HCI researchers have adopted ecological approaches, for example, to understand the influence of different social actors in the provision of childcare food practices with focus on food providers for young children (3-5 years) including five levels: the individual, interpersonal (staff, parents), institutional (workplace), community (vendors, media, professional organizations), and societal (culture, policy, regulation) level [85]. In the context of technology design, previous research has used the socio-ecological model to explore the factors that motivate or hinder the use of mental health apps between unaccompanied migrant youth [175]. In addition, the socio-ecological approach has been used to support the design of mobile technologies for paediatric asthma management [97], to explore technology development for autism [8], and better understand the interplays between technology, people, and diabetes and mental health management [13, 127]. Understanding different ecologies of care have supported researchers to deeply understand how individuals interact with their socio-technical environment (human and non-human relations) and their influence on health management and health technology design [13, 57, 173].

3 Research Context and Methods

3.1 Background, Research Settings and Participant Recruitment

In 2019, we started a project to investigate new strategies to support complementary feeding practices and reduce the risk of the DBM in IYC (6 - 23 months) in two low-resource communities in two distinct regions of Peru: 1) Manchay in Lima city in the central coastal region of Peru, and 2) the city of Huánuco in the central highlands of Peru. The project consisted of two research phases. The first formative research phase included qualitative and quantitative studies in Manchay and Huánuco to understand the drivers of DBM, looking at household food environments, caregiver behaviours, nutritional counselling in healthcare centres, and health promotion and IYC feeding practices in government-led daycare centres [147, 148]. We also assessed the implementation of double-duty actions (e.g., interventions, programmes, policies) proposed by WHO, and local priorities for government-level actions to tackle DBM in IYC in Peru [90]. Formative research identified four major challenges: 1) *High consumption of unhealthy foods, sugar-sweetened beverages and savoury snacks (fried, salty foods) in mothers and IYC*, 2) *Low prevalence of (or difficulties with) iron supplementation in IYC*, 3)

Issues with nutritional counselling and maternal wellbeing, and 4) *No way of tracking the DBM by healthcare professionals* [161].

The second research phase included a series of co-design workshops with caregivers and healthcare professionals to generate strategies to address the four challenges. Due to COVID-19 restrictions in Peru, the co-design phase started in June 2022. In this paper, we report the findings from four idea generation workshops in which caregivers and healthcare professionals (separately) co-created ideas and strategies to address the identified challenges. Ethical approval was obtained from the Ethical Review Committee of the Instituto de Investigación Nutricional (IIN) Peru (388-2019/CIEI-IIN) and Loughborough University (C19-87). The research team introduced themselves, and explained the participant information sheet and obtained written informed consent before the workshops, including voice recording and taking photos to support the analysis. Participants received fruits and water during workshops and transport costs were covered. Children received small toys or puzzles.

3.1.1 First community setting - Manchay, Pachacámac District: Manchay is an impoverished settlement in a dry and sandy valley with few paved roads, located at the outskirts of the city of Lima in the central coast of Peru. Manchay is zoned as a low- and middle-low-income settlement [32]. In 2020, 84.1% of households had an income below average: 67.6% of households (middle to low socioeconomic status) earned between S/863.72 - S/1,073.00 per month ($1 = S/3.73), while 15.4% (low socioeconomic status) had income below S/863.71 [32]. However, household income may have worsened after COVID-19 [92]. The burden of malnutrition in the Pachacamac district is alarming. In 2023, 30.6% of IYC (aged 6 to 35 months) had anaemia [51]. People have access mainly to healthcare centres run by different healthcare professionals (HCPs) including nutritionists, nurses, and doctors.

3.1.2 Second community setting - Huánuco, Huánuco District: The city of Huánuco is a high-altitude city and the capital of the Huánuco Region, located in the district of Huánuco, in the central highlands of Peru. Huánuco district has one of the highest percentages of illiteracy in Peru [93]. In 2022, the Huánuco district reported an alarming 51.8% prevalence of anaemia in IYC (aged 6 to 35 months) [94]. The main commercial activity is agriculture. While in 2020 the average income per household was S/1235 monthly (approximately $335.50) [1], in 2022 between 36.7% to 40.9% of people in the district faced monetary poverty [95]. People have access mainly to healthcare centres run predominantly by nurses, as the medical workforce is mostly concentrated in Lima [71].

3.1.3 Participants recruitment. In each community, we conducted one workshop for HCPs and one for caregivers in the main healthcare centre as it was an accessible community location. We purposely invited caregivers of children (aged 6-23 months) in the vicinity who attended for medical and nutrition consultation. Community healthcare promoters helped to recruit caregivers who they frequently visited in each community to follow up on their IYC development within their first year of life. In Manchay, we recruited 8 caregivers (all women, 7 mothers and 1 grandmother). In Huánuco, we recruited 8 mother caregivers. In addition, we recruited healthcare professionals (HCPs, excluding health promoters), who provide nutritional counselling and child health services, in coordination with the heads of the principal health centre and one subsidiary health centre in each community who allowed staff to attend workshops. In Huánuco, we recruited 13 HCPs (all nursers), while in Manchay, we recruited 11 HCPs (3 obstetricians, 3 nutritionists, a chemical pharmacobiologists, a social worker, a nurse, a laboratorist, and a technician nurse). We use HCP as an umbrella term to refer to different types of healthcare professionals as we did not use individual identifiers for the recording and transcriptions. Using purposeful sampling, our goal was to explore ideas and strategies by engaging with low-resource communities based on their lived experiences and situated context, rather than examining socio-demographic differences

or trends [139]. Aligned with exploratory co-design research in maternal and child health in low-resource communities [39, 121, 194], we did not collect additional demographic data as it was inappropriate [59] considering the existing caregiver's negative experiences with the HCPs (challenge 3) to lower the burden of participation, build rapport and trust, ensure anonymity, and prevent stereotypes to establish a collaborative relationship [108, 184].

3.2 Researcher's Positionality

The larger project team is a cross-cultural and interdisciplinary group of researchers, including seven researchers from Peru, eight from the UK, and one from France with expertise in public and population health, nutrition, social sciences, and human-computer interaction. The authors of this paper are: Three from a research institution in Peru, five from academic institutions in the UK (two of them with Latin American background), one from a French research institution. Eight out of the nine co-authors are women and five co-authors are native Spanish speakers (three Peruvian and two Latin Americans), and all co-authors speak English. All members of our research team belong to an upper-middle socio-economic background. We acknowledge that the lived experiences, values, beliefs, knowledge and background of our research team have shaped the ways in which each researcher engaged in project activities and the framing of the project and analysis processes [26, 124, 168]. Acknowledging these positions, we engaged with community stakeholders, including caregivers, healthcare professionals, and policy makers, earlier in the framing of our research to help define the scope of the co-design research phase. During this phase, we valued and prioritised the co-construction of knowledge actively with community participants. In addition, our team has extensive experience, individually and collectively, in conducting participatory research in Latin America, Africa, and Asia in maternal and child health, including conducting design workshops with the Peruvian communities represented in this paper [137, 138].

3.3 Pre-workshop activities and creation of design materials

3.3.1 A Storyboard Visualising Four Design Challenges. Traditional ideation workshops start with the identification of the problem [79, 80], or with a given problem statement [172] or a design challenge [80], mostly in text, to narrow the focus of the ideation process [16]. To facilitate the idea generation process, insights from our formative phase informed the creation of a storyboard to visualise the four main challenges to ensure a shared contextual understanding of lived experiences and a deep engagement with these issues while framing the design challenges [18, 188] for co-ideation workshops. Taking a human-centred design approach [88], we engaged with a professional graphic designer who sketched the four main design challenges (listed in Section 3.1) through several iterations and using provocative scenarios to trigger self-reflection and empathy [80], going beyond assumption-based personas for problem framing [79]. The research team and other community stakeholders provided feedback on the quality of the illustrations and their relevance to the local context. The four visual challenges of the storyboard were also validated as part of 20 household interviews[1] with caregivers from Huánuco and Manchay, conducted by the first and second authors to capture family routines and IYC feeding practices, before the workshops. In addition, the research team created narratives to complement visual scenarios based on insights from the formative research to illustrate the context, highlighting actions and interactions [68]. For example, the third challenge of the storyboard (see Figure 1) was created with a provocative edge describing a busy waiting area in a healthcare centre and visualising the issues that take place when caregivers enter to the nutritional counselling (medical paternalism and its impact on maternal well-being). Each illustration of

[1]Interviews are out of the scope of this article and are reported separately.

the storyboard was printed in black and white in A4 with the narratives in Spanish, the Peruvian official language. All participants understood the visual challenges and recognised their importance in their own context.

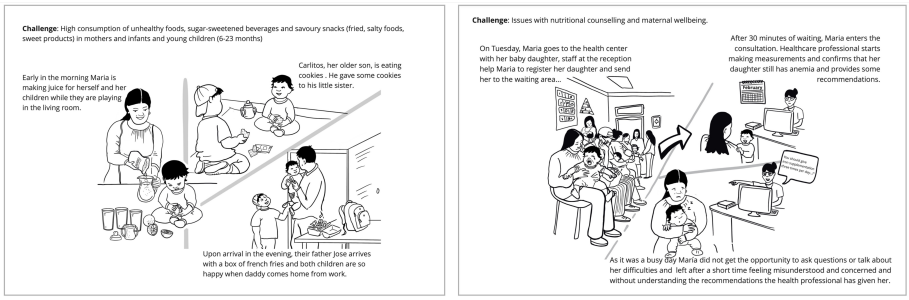

Fig. 1. Left: the first challenge of the storyboard illustrates the high consumption of unhealthy foods, sugar-sweetened beverages and snacks. Right: the third challenge visualises issues related to the healthcare centres and child consultations. The original narratives in the figures have been translated from Spanish.

3.3.2 Design Cards to Support Idea Generation. We created a set of visual and context-specific design cards [42, 84] to aid creative thinking during the idea generation workshops (see Fig. 2). By combining multiple design cards, they support brainstorming, exploration, and further development of context-dependent ideas[63]. Informed by our formative research that helped identify cards' visual representations (reported somewhere else), and inspired by previous card-based tools that support early ideation [62, 67, 72], we created 19 stakeholder cards, 9 technology cards, and 12 resources and strategies cards following a human-centered design approach [88]. In line with previous work using design cards in low-resource communities [39, 88], our aim was to keep the design cards as simple as possible by using pictorial representations [10] with simple colours (e.g., white and black) [39] to facilitate visual reasoning [42], brainstorming, shared understanding, and empathy [10, 184, 199]. We evaluated the understanding of visual representations of the cards, their interpretations, meaning, acceptability, and contextual relevance with seven interdisciplinary researchers, five healthcare professionals and 14 caregivers before the workshops[2]. The feedback sessions included WhatsApp interactions with the 7 caregivers from Manchay and Huánuco, two face-to-face group discussions with Manchay's caregivers, and an online session with HCPs. These sessions highlighted how design cards were useful to make associations between cards, and provoke discussions, reflections and empathy due to the expressions and lived experiences represented.

3.4 Idea Generation Workshops: Venues, Procedures, and Analysis

Workshops aimed to support the collaborative generation of ideas and strategies to address the visualised challenges in the storyboard. We conducted four co-ideation workshops: two in Huánuco and two in Manchay, in separated sessions for caregivers and healthcare professionals to explore the perspectives and ideas of each group and avoid potential intra-community power imbalances [39]. Each workshop lasted between 90-130 minutes.

3.4.1 Workshop locations. The two ideation workshops (one for caregivers and one for HCPs) in Manchay took place in an open room of the main healthcare centre. In this venue, the research team made space for the workshop by moving around the only available table and a couple of standing panels (see top picture in Figure 3) to separate them from the areas where caregivers would be waiting for consultation. We provided large worksheets (A0 paper) and materials (e.g.,

[2]The complete human-centred design process and evaluation of the design cards are out of the scope of this article and are reported separately

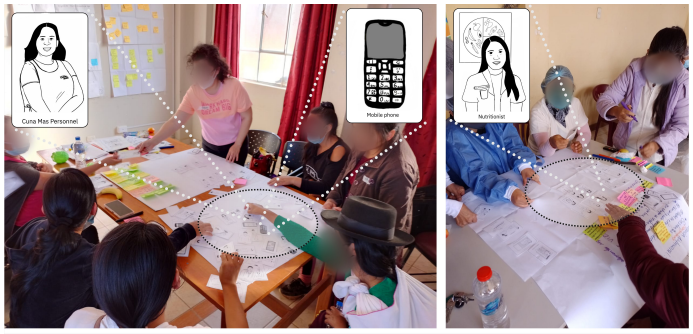

Fig. 2. Caregivers in Huánuco exploring design cards (left), and HCPs in Manchay generating ideas using the cards (right).

post-its, markers, design cards) that were placed on the table (Figure 3). In the second workshop with HCPs, it was possible to get more space for two tables (see bottom left on Figure 3).

Fig. 3. Co-ideation workshops. Top picture shows the arrangement of the limited space in the Manchay caregiver workshop using one table for two groups. Bottom left picture shows the extended space in the Manchay HCPs workshop to have one table per group. Bottom right picture show the venue in Huánuco, highlighting the workshop space and the play area.

In Huánuco, the workshops took place in the auditorium of the healthcare centre and we provided the same worksheets and materials. Based on the lessons learned from the Manchay caregiver workshop and taking advantage of the larger space, the research team set up a play area for children within the auditorium (see Fig. 3). Three health promoters helped supervise the IYC to facilitate the participation of caregivers.

3.4.2 Introduction and Overview. After obtaining informed consent, a facilitator welcomed the participants, introduced herself and the accompanying research team, and asked the participants to introduce themselves. The facilitator then introduced the main goal of the overall project. A second facilitator provided an overview of the main findings of the formative research (phase 1). Then, the purpose of the ideation session was explained.

3.4.3 Presentation of the Storyboard: Understanding and prioritisation of the challenges. Facilitators distributed the visual scenarios of the storyboard (A4 printed) to the participants to introduce the main design challenges in preparation

for co-ideation activities. Each visual challenge was discussed to explore what participants saw and understood and to reflect on their lived experiences while relating to the challenges to gain empathy [80], share stories and experiences [18]. As challenges 1, 2 and 3 relate directly to caregivers, we decided to explain and discuss only these three challenges with caregivers. All four challenges (listed in Section 3.1) were discussed with HCPs. Participants ranked the challenges by raising their hands to vote for the most important challenges from their own perspectives. The challenges with the most votes defined the problem space [188] for co-ideation.

3.4.4 Co-ideation activities. Participants were divided into two groups to start the co-ideation activities. Facilitators randomly assigned one of the top challenges to each group. In the Huánuco caregiver workshop, all caregivers stayed in one group following the advice of local researchers, as IYC required constant attention despite being supervised by health promoters. Next, we introduced the set of context-specific design cards (stakeholder, technology, resources, and strategies; see section 3.3.2) that were used to facilitate the generation and exploration of ideas. Initially, we asked participants to share and write on post-it notes [52] as many ideas as possible (divergent mode[80]) to address the challenge assigned. Participants in their groups then presented and discussed their ideas with others. To refine ideas (convergent mode [80]), participants were invited to collaboratively use a variety of materials (big papers (A0), post-it notes, and design cards) to further develop their ideas and create tangible ideation boards as creative outputs [18] (see Figure 5).

3.4.5 End of the workshop. At the end of the workshop, all groups explained and shared their ideas using the co-created ideation boards to the rest of the participants and researchers. Participants also reflected on their experiences from the workshops. Overall, caregivers perceived the co-ideation workshops as fun and a good way to socialise with other caregivers and raise awareness of IYC nutritional challenges. Although caregivers mentioned many positive experiences and congratulated facilitators and healthcare centres, caregivers in Manchay suggested getting a larger space. Healthcare professionals also shared their positive experiences and highlighted how the workshop made them reflect on many of the challenges and ideas generated.

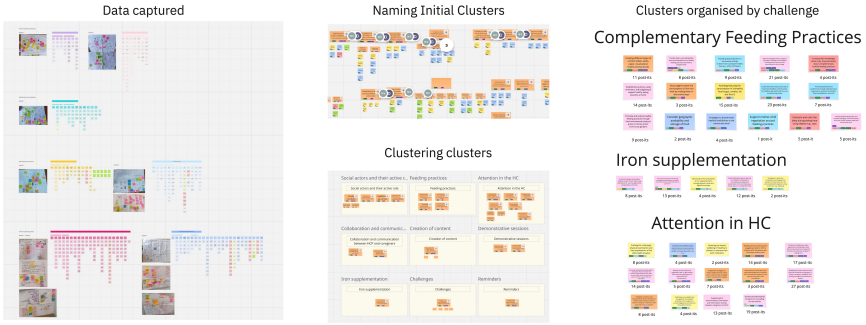

Fig. 4. An example of the analysis in Miro from the data collected to the development of clusters of ideas.

3.5 Data analysis

The first author captured pictures from all ideation boards from the workshops and transformed all the physical post-it notes into digital post-it notes using Miro (a digital collaborative platform), resulting in more than 500 digital post-it

notes. To analyse them, we used affinity diagramming [73, 77], a powerful sense-making technique to support qualitative data analysis, which is commonly used in CSCW and HCI research [44, 74, 75, 110], especially in Contextual Design [89]. Li et al. [110] characterise it as the most flexible method that is suitable for multiple stages of the design process (e.g., explore, create, implement, evaluate) to organise and make sense of qualitative data (often written on separate post-it notes) by identifying connections between ideas, and clustering them based on their affinity [74]. In the first round, the first author picked notes with ideas or strategies for addressing the challenges and noted the actors and settings that were involved, and group them into initial clusters of ideas (see Figure 4). The first and last authors commented on the Miro board and named the initial clusters and further developed them into bigger clusters of ideas through several iterations of axial coding to refine, align, and generate the final themes [5, 140, 196]. These clusters were then reorganised based on their relationships and relevance to the identified challenges resulting in (Figure 4): 35 themes (16 for design challenge 1, 14 for design challenge 3, five for design challenge 2, and none for design challenge 4). The themes were discussed in several meetings with the interdisciplinary co-authors, including workshops facilitators, who provided comments and feedback to refine themes. We consolidated the final themes upon the final writing of this paper reporting on challenges 1 and 3, the most voted during the workshops. We used transcriptions of workshop recordings (6 hours 36 min. in Manchay, and 4 hours 36 min. in Huánuco) to capture additional material (quotes) to complement ideation boards and confirm the themes using a deductive approach based on the affinity diagram.

4 Findings: Community-Based Socio-Technical Strategies to Support Early Childhood Nutrition

Our findings highlight socio-technical strategies and ideas to support caregivers of IYC to develop healthy complementary feeding practices and to enhance caregivers' and IYC experiences in healthcare centres. The socio-technical strategies outline the complexities of the social-ecological environment calling attention to the socio-material (human and non-human) and spatial (household, neighbourhood, healthcare centre, etc.) arrangements and interpersonal relationships (family, HCPs, etc.) of the existing social support systems and care ecologies that shape caregiver and IYC experiences around feeding practices.

4.1 Socio-Technical Strategies to Promote and Support Healthy Complementary Feeding Practices

In all co-ideation workshops, the challenge with the highest priority was challenge 1: *High consumption of unhealthy foods, sugar-sweetened beverages and savoury snacks (fried, salty foods, sweet products).* In the following, we present the perspectives and ideas from our diverse community participants to address the first challenge.

4.1.1 Enhancing family caregivers' practical knowledge and learning experiences around healthy complementary feeding practices. During our workshops, caregivers and HCPs highlighted the importance of enhancing caregiver knowledge (what, why, how, and when) and learning experiences about healthy complementary feeding. Caregivers want to understand what food is good (e.g., for breakfast, lunch, dinner), why they should give certain foods, and how to cook them. In the Manchay caregiver workshop, caregivers talked about *"what foods should babies eat"* (Caregivers Manchay, Ideation board 2, Fig. 5) and *"how to combine vegetables with different vitamins"* (Caregivers Manchay, Ideation board 1, Fig. 5). Participants visually depicted sociomaterial (human and non-human) elements (e.g., stakeholders, technologies and resources) using design cards to develop their ideas.

A) Enhancing dietary counselling with practical feeding recommendations and interactive sessions. Using the design cards, especially the *Demonstrative sessions* and *Informative sessions* cards, caregivers and HCPs discussed the key role of HCPs in promoting healthy complementary feeding taking advantage of caregivers' routine visits to

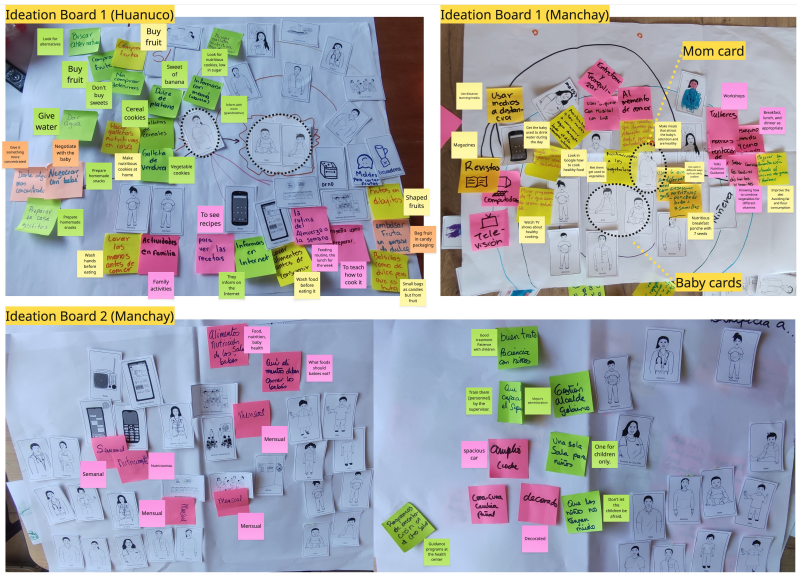

Fig. 5. Caregivers' ideation boards from Huánuco and Manchay

the healthcare centre. Participants proposed that during routine appointments, the HCPs could provide practical and doable recommendations on how to cook baby's food and how to feed the children. In the Huánuco HCPs workshop, HCPs discussed how providing information sessions could be beneficial to *"everyone in the family that plays the role of caregiver... where fathers can participate"* (HCPs Huánuco, Ideation board 1, Fig. 6). In addition, HCPs suggested that *"conducting* [cooking] *demonstration sessions of iron-rich foods"* (HCPs Huánuco, Ideation board 1, Fig. 6) could be helpful to tackle or prevent malnutrition. Manchay caregivers suggested receiving practical sessions (e.g., talks, workshops, cooking demonstrations) monthly or weekly, depending on availability.

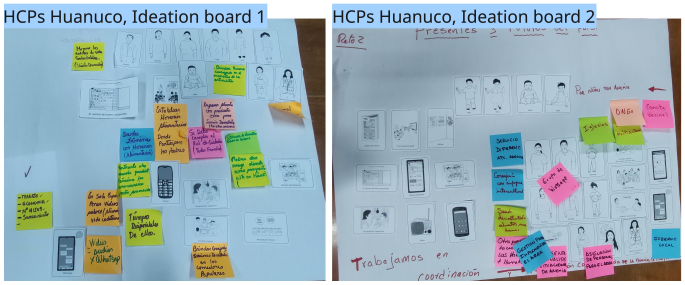

Fig. 6. Ideation boards from healthcare professionals in Huánuco

B) Moving healthy food preparation sessions and dietary counselling closer to community settings. Participants discussed the opportunities to move practical *training* sessions on healthy food preparation from the health centre to other community settings, closer to caregiver households, so caregivers and their families could attend and learn how to prepare healthy food from other community members (e.g., mothers, grandmothers) or HCPs. Furthermore,

using the soup card (part of the strategies cards), in the Huánuco HCPs workshop, HCPs suggested taking advantage of organisations that provide food at low cost, to *"provide* [dietary] *counselling and demonstration sessions in soup kitchens"* (HCPs Huánuco, Ideation board 1, Fig. 6). Another idea was providing more nutritious and healthier food (e.g., animal-source foods, fruits, and vegetables) in community settings/kitchens.

C) Combining digital and non-digital types of content to promote healthy complementary foods. HCPs discussed the importance to disseminate information about healthy food to caregivers as shown by the post-its on Manchay ideation board mentioning many times *"sugar-free"* and the need to *"raise awareness about excessive sugar consumption"* (HCP Manchay, Ideation board 1, Fig. 7). Many of the ideas and strategies captured in the ideation boards depicted different types of digital and non-digital content, including video, audio, written messages (e.g., flyers), and other more visual materials (e.g., posters, murals) to promote healthy feeding practices (e.g., at home, in the health centre, etc.; see ideation board 1, Fig. 7). For example, HCPs discussed how caregivers could receive information (e.g., what food is healthy, how to cook it, recommendations) at the healthcare centre: *"In the waiting room, put videos about nutrition and daily life"* (HCPs Huánuco, Ideation board 1, Fig. 6).

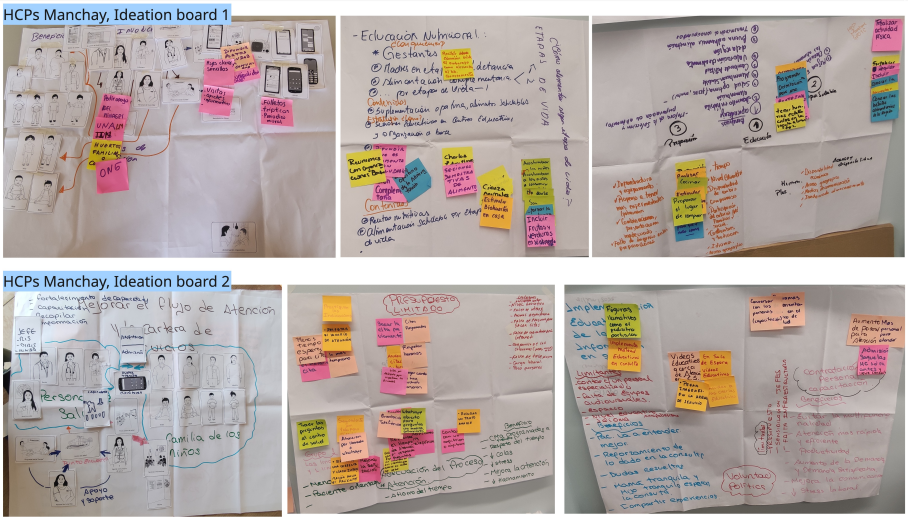

Fig. 7. Ideation boards from HCPs in Manchay

D) Developing physical and digital tools to support information seeking about healthy feeding practices according to children's development stage. HCPs and caregivers co-created and discussed ideas and tools to support information-seeking practices, especially around cooking practices for healthy food, e.g. through mobile phones or educational videos. Caregivers highlighted that they used the Internet and social media (e.g., Google search, WhatsApp), and physical books to look for baby food recipes (see Ideation board 1 from Huánuco and Ideation board 2 from Manchay on Fig. 5). For example, caregivers in Manchay wrote in the post-its that they could *"search on Google how to prepare healthy meals"* (Caregivers Manchay, Ideation board 1, Fig. 5). Visually, on the ideation board 1 of Huánuco (see Fig. 5), caregivers linked the mom card to the phone and educational video cards using lines, highlighting how to *"get information on the Internet"* and *"to watch recipes"*. Moreover, HCPs highlighted that it was important to customise the feeding information according to the children's age and give this information to caregivers in advance (see Fig.7).

Another example was to *"receive education* [early on] *from pregnancy on how to feed the baby correctly"* (see Fig. 7) and about *"timely start of feeding"* (HCPs Manchay, Ideation board 1 on Fig. 7).

4.1.2 Supporting family caregivers to develop and maintain healthy complementary feeding practices. Apart from enhancing family caregivers' knowledge, participants proposed other practical strategies to promote and support healthy complementary feeding practices at the household level by establishing routines, providing budget support, and finding and creating alternative ways to prepare complementary foods.

E) Establishing healthy eating routines and supporting their integration into the family context. Participants discussed the importance of not only understanding IYC eating habits, but also how to initiate and support the development of healthy eating habits among communities in the region. In the Huánuco HCPs workshop, a participant used the *informative sessions* card that had a circle showing healthy food, and wrote on it *schedules* and stuck a post-it highlighting the need to *"establish feeding schedules where parents are involved"* (HCPs Huánuco, Ideation board 1, Fig. 6). Furthermore, HCPs highlighted the importance of incorporating new feeding habits into family routines and their role in helping caregivers. A HCP proposed:

> *"Establish feeding schedules. Who's going to be involved? This involves the entire family environment, where parents, siblings, and grandparents will be involved. For that, you need to have... What? Give them sheets with a feeding schedule. You also need to show the mother how to use them"* (HCP in Huánuco workshop, Fig. 6).

These sheets could be enhanced using home-based physical and digital reminders such as alarms and signboards to help caregivers remember the new habit/routine they wanted to follow (HCPs Huánuco, Ideation board 1 Fig. 6 and Caregivers Huánuco, Ideation board 1 Fig. 5). For example, caregivers highlighted *"the weekly lunch routine"* (Caregivers Huánuco, Ideation board 1, Fig. 5) next to the physical reminder card. Caregivers also indicated that social interactions at mealtime with family members and other associated activities (e.g., washing food and hands) can help promote and incorporate healthy eating into daily routines.

F) Promoting healthy purchases and help with budgeting. One particular concern was to avoid and reduce the consumption of unhealthy foods by, for example, *avoiding the consumption of fats"* (Caregivers Manchay, Ideation board 1, Fig. 5). Although caregivers commented that they should *"not buy candies"* (Caregivers Huánuco, Ideation board 1, Fig. 5), they discussed that they *"often don't have enough money, so we give sweet treats because a candy costs 10 cents and a fruit often costs one Sol"* (Caregivers Huánuco workshop). Here, HCPs suggested to organise a healthy and periodic routine for purchasing healthy food, as *"you can make healthy purchases and healthy preparations."* (HCP Manchay, ideation board 1, Fig.7).

G) Supporting responsive feeding practices by entertaining and calming the baby during feeding time Caregivers expressed that it was difficult to make children eat healthily, especially vegetables. When children's acceptance of food becomes challenging, caregivers mentioned that they used a variety of strategies to convince children to eat including objects to stimulate, entertain, and calm the baby during eating time. For example, using *"musical toys with light"* or radio with the child's favourite music to entertain them while eating; in other cases, caregivers would use a cell phone to convince children to eat. A caregiver expressed: *"yes, we put his cartoons on the* [phone] *screen there, so he can eat"*. In addition, HCPs highlighted that promoting healthy feeding practices would, as a result, produce responsive feeding:

> *"Likewise, we need responsive feeding; it is the mother who must actively participate and, above all, fulfil the objective of recovering the child from the state of anaemia"* (HCP Huánuco, Workshop).

H) Enhancing the maintenance and preparation of healthy food. HCPs discussed the importance of the source, storage, and preservation of healthy food. In Manchay, HCPs discussed their limited access to food either because *"the closest store is 1 Km away"* which could be difficult to reach where there are no paved roads. Or because *"hydrobiological products don't reach certain areas..., river products do reach us but very little."* and *"not in good quality"*. In Huánuco, HCPs suggested encouraging the consumption of local and seasonal healthy foods to prepare meals with fresher ingredients at home (HCPs Huánuco, Ideation board 1, Fig. 6). In Manchay, HCPs suggested creating family or community gardens for caregivers to grow their own food, where training would be needed to help them harvest their own food. A HCP mentioned: *"Teach them* [caregivers] *to grow their own food, raising their own animals for consumption"* (HCP in Manchay).

In addition to considering the geographic location, HCPs also discussed the importance of food storage. A HCP mentioned: *"One has to teach them* [caregivers] *also* [how] *to store vegetables, fruit"* to avoid negative consequences. In addition, they believed that caregivers should also be taught how to store grains *"because it's not just a matter of keeping them in a safe place. Otherwise, they'll become infested with weevils"*. Moreover, all participants highlighted the importance of encouraging and increasing the consumption of iron-rich foods in IYC by finding alternative ways of making them. For example, *"cooked blood"* is a well-known source of iron for children. HCPs discussed how to add it to baby food (e.g., porridge) and how to *"prepare blood candy* [sweets]. *These are alternative foods. Prepare your child's treats at home"*.

I) Finding substitutes and creating alternatives to make unhealthy food and snacks healthier and attractive. HCPs highlighted the importance of working with the community to reduce or avoid sugar and salt consumption. One idea was to substitute sugar for honey as *"natural sweetener"*. Caregivers also suggested alternative and innovative ways to make food healthier and attractive for children by transforming snacks. For instance, in Manchay caregiver boards we observed how to *"use oats in different ways such as cake, cookies"* (Caregivers Manchay, Ideation board 1, Fig. 5). In addition to complementary food itself, participants mentioned that fruits are often more expensive than candies and that natural food has to compete with branded sweets' wrappers. As an alternative, caregivers suggested using cookie cutters to make interesting shapes with fruits and vegetables and using attractive packaging to provide healthy food to their children. A caregiver commented:

> *"Find some candy bags and put them* [fruit or healthy cookies] *in there* [and say to the kid] *I already bought them for you. I mean, put a candy bag, but put fruit in it. Inside, fruit or cookies we already made".* (Caregiver Huánuco workshop)

Caregivers drew new cards adding some tools (e.g., oven, blender, cookie cutters) required to make food healthy and attractive (see Huánuco Ideation board 1, Fig. 5).

J) Promoting healthy food preferences through repeated taste exposure to enhance healthy food acceptability. Caregivers and HCPs highlighted the importance of exposing babies to healthy food, and that repeated exposure of healthy food plays a crucial role in building healthy eating habits and preferences. One caregiver mentioned: *"Get* [the child] *used to the natural, sweet taste of the fruit itself"*. In the ideation boards, we found phrases like *"Give water* [to the child]*"* (Huánuco Ideation board 1, Fig. 5) or *"Getting* [children] *used to vegetables*" (Manchay Ideation board 1, Fig. 5).

4.2 Socio-Technical Strategies to Improve the Caregivers and IYC Experiences at the Health Centre

In Manchay, the second most voted challenge by HCPs and caregivers was challenge 3 related to the healthcare centre and caregiver's negative experiences *with nutritional counselling* (see Figure 1). In Huánuco, although the second most voted challenge by HCPs and caregivers was challenge 2 about *iron supplementation*, the HCPs decided to focus on challenge 3 during co-ideation activities.

4.2.1 Improving the experiences of caregivers, IYC, and HCPs before, during, and after child care appointments. **K) Helping caregivers to attend child care appointments at the scheduled time.** Caregivers wanted the waiting area to be *"less overcrowded"*, *"less waiting time for appointments"*, and *"less queues"*, etc. While HCPs commented that caregivers *"arrive late or do not arrive to their scheduled appointment"*, caregivers shared that they *"go earlier"* or *"try to arrive when there are no patients"*. As a result of unpunctuality (early and late arrivals) and non-attendance, the waiting area gets crowded, affecting patient flow and caregivers and IYC's overall experience:

> *"Sometimes they all come together, and then you have to quickly attend to the other so that the other can leave so that they don't lose their appointment... Then we rush through the consultation and don't give them the attention we should"* (HCP - Manchay workshop).

HCPs suggested to encourage punctuality according to the appointment system so that caregivers *"attend their appointments on time"* and *"respecting the opening hours"* (HCPs Manchay, Ideation board 2, Fig. 7). This could benefit IYC and caregivers by spending less time in the waiting area and less stress for them and fo HCPs.

L) Preparing in advance for consultations to have more time for caregivers. Caregivers strongly believed that it was important that HCPs had an open attitude to answer their questions and doubts. In terms of efficient use of time and how it can affect caregiver experience, HCPs discussed how important it was *"to rethink the attention time so that it is longer and the* [caregiver's]*questions can be answered"*. To make it possible, they pointed to the need for planning in advance (e.g., prepare clinical history one day before using the electronic record system) to make room for additional questions and reflection. However, each health institution assigns targets to see the highest number of patients during the day. As a result, this would increase the burden on HCPs as they need to check four patients per hour, with a maximum of 15 min. per consultation, increasing HCPs stress.

M) Enhancing HCPs communication and interactions with caregivers beyond the healthcare centre. Communication and interaction between HCPs and caregivers are key aspects of child care. HCPs and caregivers used technology cards to propose using different tools such as phone calls, WhatsApp, audio, and videos to enhance communication between caregivers and HCPs. In particular, HCPs suggested phone calls to monitor, ask questions, and provide counselling, or using WhatsApp for follow-up sessions, ask questions, provide health orientation, and share information beyond the healthcare centre. For example, when fathers are away due to their work, technology may help sharing the children's condition with them. A HCPs commented:

> *"provide guidance to the father through asynchronous calls. Let's say the father works far away, so provide counselling... send information via WhatsApp, brochures or videos"* (HCP Huánuco Workshop)

Caregivers also highlighted that cell phones are a good way to communicate with HCPs. During the pandemic, caregivers used the Internet as a means to communicate and consult with nurses. A caregiver mentioned:

> *"...now, more than anything, this [cell phone] is almost always used [...] during the pandemic, at least when our babies got sick... Sometimes you couldn't get an appointment; in the case of nurses, they used the internet [to tell us] what medication to use..."* (Caregiver Manchay Workshop)

HCPs and caregivers also highlighted the key role of health promoters in IYC nutrition. HCPs commented that health promoters are their *"support"* as *"they remind them* [caregivers]*, or they bring them* [IYC]*"* to the healthcare centre when needed (HCPs Manchay workshop). Similarly, caregivers pointed to the health promoter card stating: *"In our house, they are there, the promoters... and... They help you a lot"* (Caregivers Huánuco workshop).

N) Using visual, physical and digital materials to enhance caregivers' understanding of the child's health status. The HCPs explained how videos can facilitate understanding of what IYC can eat or not:

> *"Videos that can raise awareness in the father so that he can also tell the mother... right? Call her and tell her what her child should and shouldn't eat... "* (HCP Huánuco, Ideation Workshop)

In Manchay, the ideation board 1 (see Fig. 7) shows different physical and digital materials (flyers, posters, and educational videos) to facilitate understanding of IYC health information, beyond nutritional information, to support follow-up of treatments by caregivers at home. For example, HCPs discussed the importance of using existing resources such as "Tarjeta de control [Check-ups Card]" and "El Camino del buen crecimiento [pathway to a healthy growth Card]" to support caregivers in understanding children's health status and that these tools should be used during and outside of the consultation to reinforce the information received during the consultation.

4.2.2 Strengthening human and physical healthcare infrastructure to provide more inclusive child care services. **O) Enhancing the physical and human healthcare infrastructure and supporting caregivers navigate the healthcare centre.** Caregivers highlighted the importance of improving the physical infrastructure of the healthcare centre. For example, increasing medical specialists, having more space, getting equipment (e.g., ultrasound machines, ambulance), and improving physical conditions (e.g., hygiene). A caregiver expressed:

> *"We've seen what the health centre lacks here: improving care and the lack of consulting rooms. Because we see that we come here with earaches, there is no specialist, and there is no specialist in vision either. We've seen that sometimes we have come for an emergency, and the ambulance has a missing tyre or something, and we have to go on our own"* (Caregiver, Manchay workshop).

In addition, caregivers suggested customising and creating spaces for children to play and get entertained while waiting. For example, creating a room/space for children, with additional objects (e.g., toys) that could be used when they are waiting for their consultation to get them distracted. Furthermore, HCPs highlighted the importance of improving signage in the healthcare centre using clear and simple messages with attractive illustrations. For example, *"Signage with boards explaining the location of the services offered by the health centre"* (HCPs Manchay, Ideation board 2). A HCP highlighted that this would benefit in a way that a caregiver *"is not confused or in doubt about where she entered, where she is going"* (HCP Huánuco Workshop). Moreover, caregivers and HCPs highlighted the importance of increasing the number of health personnel (e.g., more nurses) and specialists (e.g., dentists, paediatricians) in the health centre, to be able to attend a larger number of IYC. Last, HCPs created an *"anfitrion"* (host/receptionist) card (see Ideation board 2 in Fig. 7) to show that the healthcare centre needs to hire a person who can inform and help people where to go when they have an appointment, rather than asking nurses and doctors who are busy attending other patients.

P) Building empathic engagement and interpersonal skills for HCPs to enhance their interactions with caregivers. HCPs and caregivers discussed the need to build capacity and develop empathic skills among HCPs to enhance interactions with caregivers and the treatment at hand. These included raising awareness among HCPs, promoting kindness in communication, and improving the general attention that caregivers received. HCPs considered training in communication and technical skills necessary to improve the treatment and overall experience of caregivers

and IYC at the healthcare centre. For instance, they highlighted the need to *"let the supervisor train them* [to HCPs]*"* and that HCPs should have *"good attention, patience towards children"*. This would also benefit IYC so that they would not be afraid of treatment.

Q) Advocating for an intercultural and personalised approach to develop HCPs counselling competencies In Huánuco's ideation board 2 (see Fig. 6), next to the different caregivers cards (e.g., mother, father, grandmother, siblings), HCPs discussed that it is crucial to develop personalised approaches and cultural competences for counselling to enhance the delivery of childcare services. A HCP in Huánuco mentioned:

> *"We want to have a differentiated service for anaemia care that provides counselling with an intercultural approach. In this sense, it will also be specialised care for the area... the beneficiaries will be all children, who in turn are the present and future of the country" (a HCP in Huánuco)*

In addition, HCPs also suggested adapting and adjusting healthcare service delivery (e.g., space, human resources, treatment, etc.) to the specific characteristics and needs of children with anaemia. For instance, a HCP mentioned:

> *"How are we going to make this differentiated service for anaemia care work? For this, we are going to use the controls* [check-ups]*and show the control card* [check-ups card]*... also posters where the difference between children with anaemia and children without anaemia can be shown"* (HCP Huánuco Workshop)

R) Developing an action plan and negotiation skills to get funding from external organisations. HCPs and caregivers often need to navigate other structural challenges. In three of four HCPs' ideation boards, participants highlighted the role of policy and government institutions related to the quality of care in the health centres. Participants created new design cards with the names of those institutions (e.g., RIS, DIRIS, MINSA – acronyms in Spanish) that can provide funding to improve the infrastructure of healthcare centres. HCPs also referred to the need for capacity building to develop negotiation skills to gain support of local organisations, such as the Ministry of Agriculture of Peru, among others, to develop programmes in favour of IYC health.

5 Discussion

Our findings presented community-based socio-technical ideas and strategies to address challenges in IYC nutrition in low-resource communities in Peru from the perspectives of caregivers and HCPs. Our findings highlight how the socio-technical strategies require collaboration across multiple distinctive and dynamic elements of caring ecologies, including: primary caregivers (mothers and fathers), family caregivers (e.g., grandparents, siblings) and HCPs (e.g., nurses, doctors, health promoters), and other community (e.g., social organisations) and societal actors (e.g., governmental institutions, etc.), as well as non-human (digital and non-digital tools/materials, food, information, programmes, etc.) resources, across different spatial (household, community, healthcare centre, etc.) arrangements that shape caregiver and IYC nutrition and health experiences. Figure 8 visualises the complexity of caring ecologies in IYC nutrition by highlighting the different social worlds that interact and overlap with each other, and how the enactment of the socio-technical strategies (digital and non-digital) requires the involvement of multiple socio-material actors to make interventions work in context. We extend previous HCI research understanding IYC nutrition [85] and complex care ecologies [57, 173, 174] to support the design of digital health technologies [8, 13, 97, 175] and ecosystems [133], taking a socio-material approach [114, 118].

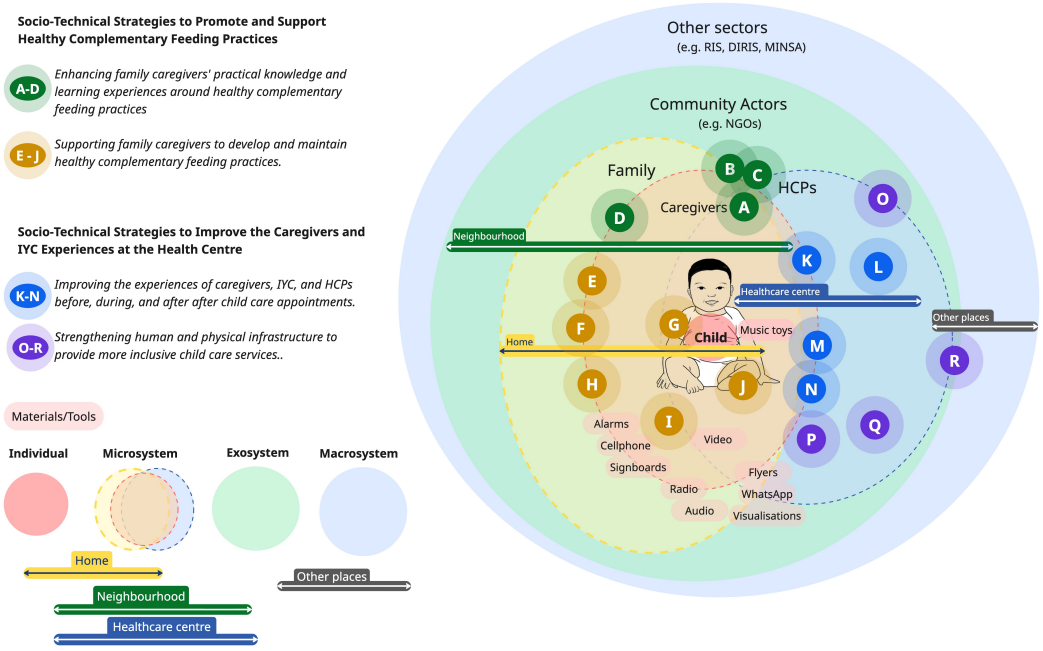

Fig. 8. Sketching caring ecologies: socio-material and spatial elements that shape IYC feeding practices

5.1 Reconfiguring and Negotiating Socio-material Resources and Responsibilities in Caring Ecologies

In contrast to previous work on digital maternal health that focus mostly on the mother caregiver [35, 60, 82, 177, 183, 200], all ideation boards highlighted how the mother card was continuously surrounded by post-its or connected to other design cards and post-its and no single idea or strategy focused only on the mother. The socio-technical strategies (see Figure 8) point to the important involvement and collaboration between multiple stakeholders (e.g., fathers, family members, and different HCPs) showing how care responsibilities extend to other actors beyond traditional gender norms and expectations from mothers [53, 113], and beyond traditional notions of responsibility that promote the 'autonomous' individual [186]. Taking the perspective of relations of care [186] in IYC nutrition and health, our findings highlight how multiple social material agencies and practices of care ecologies intersects and interact through ongoing relationships (caregivers/child, caregivers/HCPs, family caregivers/child, caregivers/IYC/HCPs, etc.) recognising what needs to be done to help others [186]. For example, when cards representing family caregivers (older sibling or grandparents) were used as caregivers for IYC [55]. However, Figure 8 also shows how the responsibilities of care overlap across family and community actors, where trust and collaboration are required to manage and prevent potential conflicts across these ongoing relationships (e.g., between family members or between caregivers and families with HCPs). Thus, technologies alone (or one-size-fits-all approaches) are not sufficient to support socio-material complexities of IYC nutrition and health.

The materiality of everyday environments can enable, support or restrict care practices [28]. Aligned with [27, 28], our findings shows the importance of making visible the materiality of everyday spaces (e.g., household, neighbourhood, healthcare centre) and their important role in configuring care and supporting IYC nutrition. As illustrated by the third

challenge (see Figure 1, right), different issues occur in healthcare centres that influence caregivers' engagement and experiences that often discourage them from asking questions. During our workshops, the health centre was visualised as an important place to promote IYC healthy nutrition through material and non-material practices to facilitate the family understanding IYC nutrition and the child's health status and enhance caregiver's and IYC experiences of care advocating for a more inclusive and personalised approach. Participants also highlighted the need to bring dissemination strategies closer to communities by facilitating the work of other actors (e.g., health promoters) or by enhancing existing social programs (e.g., Juntos [142]). Many strategies placed HCPs as the bridge between beneficiaries (e.g., IYC and their families) and the tools proposed (see Ideation board 1 in Fig. 7). In other cases, technology was highlighted as a mediator and supporting tool [143] between HCPs and IYC and their families (see Ideation board 2 in Fig. 7) to enhance IYC nutrition practices.

As digital health is often disconnected from the complexities of healthcare settings [130], our findings add to recent calls to take socio-ecological [13, 127, 175] and socio-material [114, 118] approaches to understand and design digital health, and therefore avoid technological determinism [183]. In making sense of our findings, they closely align with the social ecology of child health and wellbeing [54] that highlights the importance of looking at different everyday contexts in which children grow up to improve health and wellbeing. Although a socio-ecological approach brings attention to understanding individual, interpersonal, institutional, community, and societal factors that influence infant feeding practices [126] and how childcare providers prepare and serve food [85], its visual representation may not be sufficient to aid the design, development and adoption of healthcare interventions. Figure 8 illustrates how our analysis brought attention to the situated social and material agencies and practices of local care ecologies (e.g., stakeholders, artifacts, digital systems, different settings) and visually represent their dynamics by highlighting the spatialities of care [27] and relations of care [186] that shape caregivers and IYC care experiences. Apart from highlighting the actors and settings of care ecologies in Figure 8 , the socio-technical strategies visualise the interplay between multiple actors and settings that are continuously reconfigured and their different purposes, bringing attention to how the virtual context [128] and digital tools (e.g., WhatsApp or video calls) can become an integrated actor [143] in supporting IYC care practices within and beyond the situated healthcare infrastructure [11].

5.2 Socio-Technical Implications to Support and Enhance Childhood Nutrition and Health

Our findings emphasise the socio-material aspects of the proposed strategies and the key role human and non-human resources including technology as mediators of care practices. First, our findings show the importance of supporting caregiver information-seeking practices not only on how to properly feed their IYC, but more importantly, how to prepare and buy healthy foods. For example, caregivers discussed the use of social media to get information and how they searched for recipes online [185]. However, these strategies may put caregivers and IYC at risk of consuming unhealthy complementary foods due to issues related to the reliability of information (e.g., poor content, incorrect information) [35]. Unlike digital strategies that primarily aimed at the mother caregiver [60, 177, 200], our findings highlight the importance of the situated collective relations of care ecologies (e.g., family, HCPs) and the key role of HCPs in the dissemination of evidence-based information. Thus, our findings suggest that digital health that supports information-seeking practices around IYC nutrition should use community-based or participatory design approaches to re-design complementary feeding guidelines [158] to make healthy food more flexible, attractive, and doable for caregivers and IYC. In addition to providing reminders and healthy purchases, the creation of recipes (video and audio) that could be shared within their communities, requires feedback from HCPs to ensure that any information and recipes are personalised to the age, needs, and developmental stage of IYC to be relevant to caregivers [82, 195].

Second, our findings also highlight the importance of experiential learning and suggest complementing the nutritional information with practical sessions, such as cooking demonstrations at the healthcare centre or community settings. These sessions can be recorded and shared (e.g., using WhatsApp) with family caregivers who cannot attend in person using short videos [82]. Our findings suggest that digital health should be designed to support the experiential learning of caregivers leveraging socio-material practices of everyday environments. For example, using lectures, pictorial interactive sessions and other physical demonstrations, as suggested by participants, has shown positive results enhancing the complementary feeding knowledge and practice of caregivers [164]. The use of visual, physical, and digital materials within and beyond the consultation can also support caregivers' understanding of IYC nutrition and children's health status.

Third, our findings also highlight the importance of encouraging iron-rich food consumption among IYC and familiarising them with different types of healthy food. Here, family caregivers play a key role as family activities such as mealtime routines could be used to facilitate these strategies. Our findings suggest developing healthy food preferences by leveraging repeated taste and non-taste exposure techniques to help build healthy eating habits in IYC. Taste exposure and sensory learning techniques such as visual exposure have shown positive results in increasing vegetable intake [129]. Visual exposure could be mediated by technology using eBooks [120] or touch screens [40, 58] to support healthy eating. In addition, nutritional programmes could be enhanced by improving existing health-promotion outreach services to make health services closer to the communities, accounting for food maintenance practices, and using emerging technologies such as shape-changing food [192] and 3D food printing [103] to change the form of healthy food to make complementary foods attractive.

Fourth, participants proposed ideas (using toys, sounds, or phone) to help caregivers entertain children when eating. Here, HCPs suggested applying responsive feeding, defined by WHO as an approach in which caregivers encourage children to eat autonomously in response to their physiological and developmental needs (e.g., appetite signals), to support children's self-regulation [135]. Our findings suggest that digital health should be designed to support responsive feeding by enhancing child-caregivers' interactions during feeding practices. Although strategies could provide actionable recommendations and help develop positive practices and experiences of responsive feeding (supporting mindful eating), it is necessary to avoid distractions while feeding IYC and the use of the phone might not be always recommended [141]. For example, parental screen use during family mealtime has been associated with negative feeding practices (e.g., use of pressure to eat) [191], and with negative outcomes such as overweight [190]. Thus, enhancing child-caregiver interactions during feeding practices requires caregivers to be fully present to foster a warm and responsive feeding behaviour and context-aware scheduling systems [107] can pause notifications on caregiver's phone to avoid interruptions while feeding their babies.

Last, although some strategies highlighted the need to build capacity of HCPs for particular conditions (e.g., anaemia), there is a need to recognise and build capacity for other conditions (e.g., obesity and overweight) and to improve empathic skills. Our findings suggest the need of an intercultural approach that could help develop empathetic skills among HCPs. As highlighted by the storyboard (see Figure 1), careful attention should be given to addressing the socio-material challenges (e.g., lack of time, space, and human and non-human resources) that negatively influence the development of empathy [125]. This requires enhancing national and state-level policies and programmes to promote an intercultural approach, tailored to the needs of HCPs and local communities within the situated care ecologies. This will promote empathetic communication and relationships between caregivers and HCPs, which is crucial for IYC nutrition and health [158].

Overall, digital health has the potential to address inequities in maternal and child health in Latin America [31]. However, digital technologies can be seen as tools for justice and injustice especially when engaging with low-resource communities [132]. Taking a collaborative approach, design needs to be *"guided and facilitated from within the community"* [47] to foster social justice [36] from the start of a project and grounded in the situated care ecologies to provide more holistic, multi-faceted, and socio-technical support to improve IYC nutrition.

5.3 Strengths and Limitations

One of the main strengths is the active involvement of caregivers and HCPs during workshops, and the contextual adaptation and development of design materials that facilitated co-design in low-resource settings [184]. Based on observations from the first caregiver workshop, we set up a playground [194] to supervise the IYC in Huánuco to facilitate caregiver participation. As our exploratory study is situated within an interpretive research paradigm, we acknowledge that, as facilitators and external actors, we may (unconsciously) influenced HCPs and caregivers' participation [117] and we aimed to strike a balance in facilitation and active participant involvement. Rather than focusing on one particular IYC condition (anaemia or obesity/overweight), our study shows the importance of looking beyond single conditions and individual strategies and solutions. Other limitations include time constraints, as we learned that workshops should not be longer than 2 hours, as IYC start getting impatient, and the limited space in Manchay, might have influenced discussions and co-ideation activities. Although healthcare centres were accessible and promoted spontaneous participation, they could have also influenced participants' willingness to share negative experiences. To prevent this, we continuously reassure participants about the confidentiality of the discussions, highlighting the importance of their perspectives and lived experiences, and made efforts to reduce potential power imbalances by conducting the workshops separately for HCPs and caregivers. We also acknowledge the potential for translation bias as our positionality may have influenced our interpretation, potentially leading to cultural and income biases. Last, our study was conducted in two low-resource settings in Peru and are not generalisable. Future studies should investigate the challenges and strategies to improve IYC nutrition and health in other geographical regions of Peru and Latin America.

6 Conclusion

Using a co-design approach, this study explored the perspectives and ideas from caregivers and HCPs to address challenges in IYC nutrition in two Peruvian low-resource settings. We report socio-technical strategies to *promote and support healthy complementary feeding practices* and *improve the caregivers and IYC experiences at the health centre*. Our findings extend previous work by highlighting how the socio-material and spatial aspects of care ecologies shape IYC nutrition and caregivers and IYC care experiences.

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