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Effective vaccine management through social behavior change communication: Exploring solutions using a participatory action research approach in the Solomon Islands

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ABSTRACT

Addressing vaccine management bottlenecks, including high vaccine wastage rates, has traditionally been addressed through health worker training and other didactic methods of technical assistance or support as required. It has been shown, though, that the high level of technical skills, expertise, and responsibility required in vaccine handling and management cannot be achieved by mere didactic learning. While gains have been made in vaccine management and handling with these approaches, there remain challenges of high vaccine wastage rates and poor vaccine management practices across the board. Interestingly, approaching vaccine management through social behavior change has not been documented. Through Participatory Action Research (PAR), which is increasingly being used in health sciences, we explore an attempt at strengthening vaccine management and thus reducing high vaccine wastage rates by working together with health workers to identify plausible, realistic solutions to vaccine management through social behavior change. Select health workers directly involved with the immunization program in the four major provinces of the Solomon Islands were identified purposively to use action media and come up with concepts and materials for social behavior change communication that will have an impact on effective vaccine management and reducing wastages. This is the first documented use of such methodology in addressing vaccine management issues.

1. Introduction

Vaccines have been shown to have up to 44 times return on investment (ROI) using a full-income approach and 16 times greater than incurred costs using a cost of illnesses averted approach [1]. In both situations, vaccines produce much greater benefits per dollar spent, making immunization one of the most effective public health interventions known to man. To fully realize these benefits and ROI, full-cycle investments need to be made in ensuring optimal management and handling of vaccines. Some of the investments needed include increasing human resource capacity to effectively and efficiently handle vaccines for safe administration, among other immunization supply chain strengthening processes [2]. Vaccines remain the major cost drivers of any immunization program; as such, reducing their wastage is crucial [2,3]. As shown in many settings, including the Solomon Islands, wastage studies conducted in Nigeria showed a higher wastage rate than expected for vaccines in the range of 18 to 35% for all vaccines reviewed [3]. In this study by Wallace et al., the higher wastage rates were found to be attributed to some factors which majorly highlight the inadequate implementation of vaccine management guidelines by health workers [3]. Similar wastage rates from

Abbreviations: BCG, Bacillus Calmette–Guerin; bOPV, bivalent Oral Polio Vaccine; C4D, Communication for Development; CWC, Child Welfare Clinic; CWC, Out-Patient Department; EEFO, Early Expiry First Out; EPI, Expanded Programme on Immunization; EVM, Effective Vaccine Management; EVMA, Effective Vaccine Management Assessment; Gavi, Gavi, the Vaccine Alliance; HCC, Honiara City Council; HPV, Human Papilloma Virus; IPV, Inactivated Polio Vaccine; LMIC, Low- and Middle-Income Countries; MDVP, Multi-Dose Vial Policy; MHMS, Ministry of Health and Medical Services; OPD, Out-Patient Depa**rtment; PAR, Participatory Action Research; PCV, Pneumococcal Conjugate Vaccine; ROI, Return on Investment; SBCC, Social Behavior Change Communication; SIDS, Small Island Developing State; SOPs, Standard Operating Procedures; UNICEF, United Nations Children's Fund; VVM, Vaccine Vial Monitor; WHO, World Health Organization.

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unpublished reports were found in the Solomon Islands, a small island developing state (SIDS), with wastage rates of multidose vials higher than single-dose vials [4]. In the same report, wastage rates recorded for the Solomon Islands were due to expired doses, doses discarded due to power outages/power off, and opened vial wastages, among others. These wastages are mostly attributed to health worker/cold chain officer's attitudes and possible laxity in adhering to guidelines or SOPs amenable to behavior change modification. Vaccine wastages are classified as either "opened vial" or "unopened vial" wastages [5]. While opened vial wastages occur at the point of service delivery, unopened vial wastage could occur at any level of the supply chain during transport, storage, or delivery [5]. Table 1 summarizes the reasons for each type of vaccine wastage.

The accepted wastage rates for vaccines as recommended by the World Health Organization (WHO) are 5% for single-dose liquid vaccines, 15% for liquid multidose vaccines, and up to 50% for lyophilized multi-dose BCG vaccines [6]. As countries more often report higher wastage rates than recommended due to practical reasons, a recommendation to develop new methods for estimating vaccine wastage rates to guide countries in applying more realistic wastage rate estimates for better planning was endorsed by the Strategic Advisory Group of Experts on immunization (SAGE) in 2015 [7]. Nevertheless, wastage rates reported by countries are often very high and will need to be better managed to achieve universal immunization coverage.

The Solomon Islands national immunization program delivers the following vaccines to children as per the national immunization policy including traditional vaccines such as Baciliette-Calmette Guerin (BCG) for tuberculosis, bivalent Oral Polio Vaccine (bOPV) for polio, hepatitis B vaccines, measles-rubella and Tetanus-diphtheria; and the more recent new vaccines including Pneumococcal vaccines (PCV), and inactivated Polio vaccine (IPV). Human papillomavirus vaccines (HPV) have recently been introduced for girls to protect against cervical cancer, and a Rotavirus vaccine introduced to protect children against diarrhea [8]. All vaccines for the Solomon Islands, except for the Gavi-supported ones, are procured and delivered through the United Nations Children's Fund (UNICEF) managed vaccines independence initiative (VII), which is a pooled procurement mechanism for vaccines, with other essential medicines, added more recently. Thirteen Pacific Island countries, including the Solomon Islands, benefit from the VII procurement of vaccines, and buffer stocks as well. UNICEF provides technical assistance to the governments in forecasting, distribution, and storage of these vaccines. Additionally, the Solomon Islands being a Gavi-eligible country in the accelerated transition phase, receives the Gavi supported vaccines of IPV, PCV, HPV, pentavalent, and rotavirus vaccines directly procured and delivered through regular UNICEF procurement services. Annual vaccines forecasting happens using the Gavi new vaccines renewal portal and the UNICEF vaccine forecasting tool. Estimated wastage rates assumptions are used which are generally higher than recommended, ranging from 10% for single-dose liquid vials to 90% for 20-dose lyophilized BCG vials. These wastage rates are assumed due to the small sparse and often remote island populations, coupled with the difficult logistics of vaccine transport and storage; and were corroborated by the recently conducted vaccine wastage study in the Solomon Islands [4]. Vaccines and supplies are delivered through a three-tier system from the National Medical Stores to the 18 Second level medical stores and finally, to over 350 service delivery points or health facilities [9]. Vaccines are distributed in a bundle with other medical supplies. For most antigens, the country has vaccination coverage greater than 80% [10].

Numerous reports have emphasized strengthening the immunization supply chain through improving the skills and competencies of health workers in the normal top-down approach [3,4,11]. The Solomon Islands effective vaccine management assessment (EVMA) of 2017 identified key strengths of the immunization supply chain to include the storage of vaccines and diluents at safe temperatures, sufficient cold chain and dry storage, and adequate infrastructure [12]. The 2017 EVMA however identified key areas needing strengthening to include vaccine stock management, preventive maintenance, and support functions to be achieved through the development, dissemination, and application of context-specific standard operating procedures (SOPs). This together with findings from vaccine wastage studies and other effective vaccine management assessments (EVMAs), however, seems to suggest health worker behavior modification as a crucial step to achieving effective vaccine management (EVM) and handling, thereby reducing wastage and guaranteeing better vaccine security. This study, a first of its kind, explores the use of participatory action research (PAR) methods of working together between facilitators and health workers to identify plausible, realistic solutions to vaccine management issues through social behavior change. PAR has previously been used in immunization to help identify strategies to improve vaccination rates [13].

Table 1
Types of Vaccine Wastage [Recreated from the World Health Organization publication on Monitoring Vaccine Wastage at Country Level: Guidelines for Programme Managers.]

Vaccine wastage in unopened vials	Vaccine wastage in opened vials
• Expiry • VVM indication • Heat exposure • Freezing • Breakage • Missing inventory • Theft • Discarding unused vials returned from an outreach session	In addition to the types listed in the previous column: • Discarding remaining doses at the end of a session • Not being able to draw the number of doses indicated on the label of the vial • Poor reconstitution practices • Submergence of opened vials in water • Suspected contamination • Patient reaction requiring more than one dose

2. Material and methods

This study uses participatory action research (PAR) approach, which is based on self-reflection, data collection, and action aimed at improving health through the involvement of people who take action to make improvements [14]. The 'Action Media' methodology, which has its roots in the participatory approach, was used to explore audience perspectives relevant to solving vaccine management issues, fostering critical thinking and problem-solving, which was then immediately transformed into context-appropriate social and behavior change communication (SBCC) strategies and resources. Action Media methods use a series of sessions to focus on developing trust between participants and facilitator(s) towards stimulating critical thinking, reflection, and problem-solving. Elements include activities such as small and large group discussions, mapping of contexts and challenges, energizers, and creative exercises, which lead to the development of communication concepts [15,16]

2.1. Conceptual and analytical framework

We used the Socio-ecological model (Fig. 1) to guide the assessment, analytical review, and interpretation of the data [17]. We targeted identification of drivers of barriers to effective vaccine management with particular attention to cross-cutting factors: Information needs, Motivation, Ability to Act, and Social Norms.

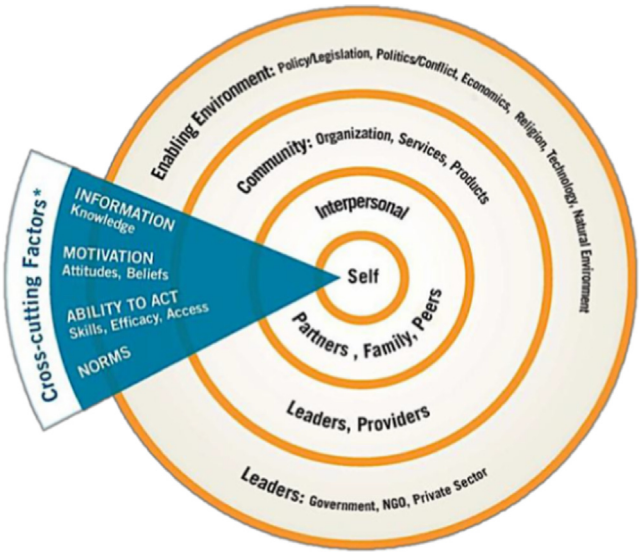

Fig. 1. The Socio-ecological model [Retrieved from McKee et al. (2000). The social-ecological model assists in providing the framework for understanding, exploring, and addressing the social determinants of health at any level]

We had a keen interest in the characteristics of adopters of EVM (see Figs. 2 and 3).

2.2. Study objectives

The objectives of the participatory sessions were centered around finding ways of addressing vaccine management issues and reducing vaccine wastage, in the clinics, and during immunization sessions, among health workers and cold chain officers in the Solomon Islands. It was emphasized during the sessions that any interventions to reduce vaccine wastage should result in a more efficient service delivery, and not to reduce immunization coverage and community protection. The study objectives included;

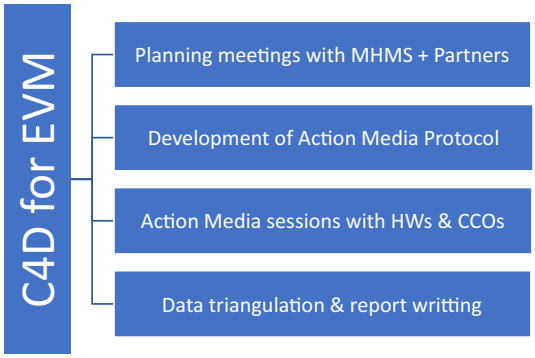

Fig. 3. *Step-by-step process in the planning and implementation of PAR for Vaccine Management* [C4D for EVM summarizes the steps involved including planning, protocol development, action media sessions, and reporting]

- To document specific health worker practices that contribute to vaccine wastage
- To identify practical solutions to current negative health worker practices that lead to vaccine wastage, thereby contributing to improved immunization coverage.
- To develop communication materials and tools that health workers can use to reduce vaccine wastage without negatively impacting on vaccination coverage.

2.3. Study format and participants

Initial concept development started in October/November 2019 with an initial discussion led by the UNICEF Maternal and Child Health Specialist and Communication for Development Consultant. Preliminary meetings were held with the Ministry of Health Medical Services (MHMS) and selected partners during which the approach and objectives of the Action Media sessions were shared and discussed for buy-in and active participation. Afterward, an Action Media protocol was developed and reviewed with the team internally.

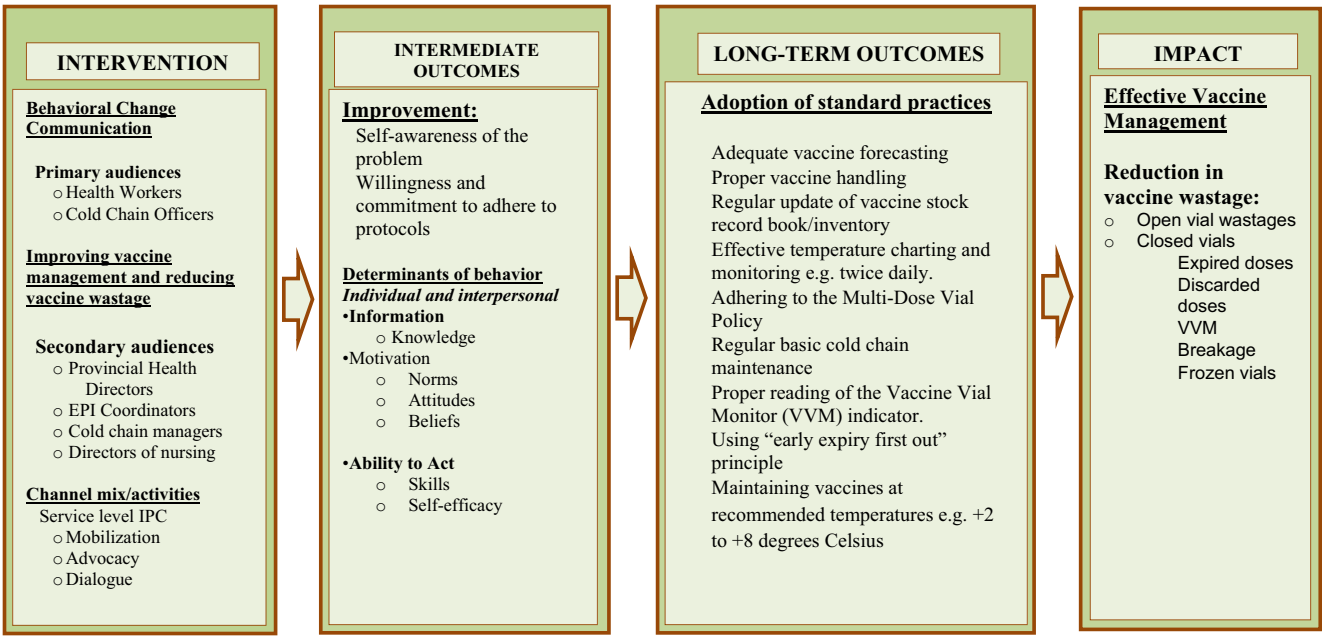

Fig. 2. *Conceptual Theory of Change for this Study* [This conceptual framework shows the inter-relationships between the proposed interventions, outcomes both intermediate and long-term, and impact of the interventions. It depicts the theoretical assumptions and potential outcomes of interventions.]

Following the endorsement of the protocol by the MHMS, a representative sample of 15–20 health workers and vaccine handlers or cold chain officers were recruited by the provincial health teams across the four largest provinces of the Solomon Islands namely; Malaita, Western and Guadalcanal provinces, and Honiara city council (capital). Recruitment was through the Ministry of Health and Medical Services (MHMS), supported by Provincial Health Directors, EPI Coordinators, Child Health Officers, and Health Promoters. Purposive selection of a spectrum of health workers directly involved in vaccine management was done, with variations in gender considered. Forty-two (42) participants from the four provinces attended the sessions.

Malaita and Western provinces had one separate session each, while Guadalcanal and Honiara city council had one combined session. Each session is a three-day-long interactive engagement lasting 5 – 6 h per day and sessions were conducted based on a structured agenda format (See Appendix B). In all, each session lasted a week, including travel to and from the respective provinces, a total of 3 weeks for the three sessions. Sessions were conducted in February and March 2020.

These four provinces account for over 70% of the total projected population of the Solomon Islands [18]. Recruitment of participants was made with special consideration given to relative homogeneity of the participants, including taking into account similarities in assigned work function or duties, among other factors. Appropriate venues that allow for full engagement and participation were identified and used in the three occasions. Two data transcribers were engaged in supporting the process. A graphic designer or illustrator worked to transform initial ideas and images by health workers to proper communication materials.

2.4. Materials required for the sessions included:

1. Audio recorders
2. Camera
3. Flip charts
4. Markers
5. Masking tape

2.5. Ethical considerations

Participatory Action Research sessions are a formative activity guided by ethical principles and guidelines [19]. At the beginning of the sessions, we made participants aware of their rights to participate freely and their rights to privacy. The facilitator(s) clarified to the group that contributions made would not be linked to any person's name and that participants should respect the right to the confidentiality of group members as a whole. For any photographs taken during the sessions, we sought consent from the participants and informed them that such material was intended for describing the research process, including informing UNICEF and the Ministry of Health and Medical Services (MHMS) reporting. We also recorded session components via digital audio recorders, translated, and transcribed to aid the research process. We provided participants with refreshments and meals during sessions, and also reimbursed their travel costs and living expenses for the duration of the sessions.

2.6. Analysis and interpretation of data

We analyzed data in two steps;

- Step 1 occurred as data was generated during discussions with study participants; it was immediately translated into simple tools and communication materials (posters inclusive of messages - see pictures in Appendix C below).
- Step 2 of data synthesis occurred when data was subjected to content analysis and review of emerging insights and key messages/materials suggested by participants. We further subjected data to qualitative analysis using logical matrices.

3. Findings

The sessions were facilitated by a lead facilitator and five cofacilitators – two from the Solomon Island Ministry of Health and Medical Services (MHMS) and two from UNICEF. Both lead and co-facilitators had briefing meetings at the beginning and end of sessions to compare shared thoughts and make any suggested adjustments or improvements in the process. Ordinarily, Action Media requires a minimum of two facilitators. Three sessions were conducted, one each for Malaita and Western Provinces, while Guadalcanal and HCC had a combined session. A total of 42 participants joined the three sessions in the four provinces. Tables 2 and 3 below show participant distribution by gender and functional roles.

English was the preferred means of communication during plenary, and participants were free to use any local language or pidgin during small group discussions. The consensus was reached on 'rules' among participants, including respect for points of view of all participants, confidentiality of personal information, attendance and timekeeping, guidelines for participation, and roles of the research team. Photographic and audio documentation of the forthcoming sessions was also clarified. Participants requested to include opening and closing prayer during the sessions.

3.1. Step 1

The focus of the first step was to introduce the participants and facilitators, including the purpose of the Participatory Action Sessions process. An introduction game was conducted comprising pairs of participants and (co)facilitators drawing an image of their partner, obtaining their name, and finding out a few details about their work, background, and family life. Participants then introduced each other to the group. The exercise acted as an icebreaker and contributed to a free and conducive atmosphere for both the participants and facilitators. Facilitators provided an overview of the forthcoming sessions, followed by a general discussion on vaccine management and wastage situation in the country. Here, the relevant findings and recommendations from the latest EVMA were highlighted including the need to strengthen stock management and other support functions. Key findings from the vaccine wastage assessment were also presented. Participants were then divided into two teams of six each while observing gender and

Table 2
Participants by Gender and by Province.

	Malaita	Western	Guadalcanal & HCC	Total
Males	9	7	2	18
Females	7	7	10	24

Table 3
Participants by Functional Roles.

	Malaita	Western	Guadalcanal & HCC	Total
Provincial EPI Officer	1	0	1	3
Cold Chain/Pharmacy Officers	2	1	0	3
Zonal Supervisor	2	0	4[a]	6
Health Promoter	2	1	1	4
Frontline Nurse/Nurse Aide	9	12	6	27

[a] Four clinical nurses-in-charge participated, with no zonal supervisor.

functional roles diversity. Each group was tasked to identify current health worker practices that contributed to poor vaccine handling and wastage. After identifying and listing current negative practices, they were then tasked with suggesting practical behavioral solutions to such practices which were then shared with the whole group during plenary.

3.2. Step 2

The focus here was to stimulate critical thinking and creativity. An energizer was conducted at the start of the session. Participants were asked to use the identified practices and solutions to develop communication materials and tools of their choice that can be utilized to improve vaccine management and reduce vaccine wastage. These materials contain guidelines or reminders on effective vaccine management. The focus practices addressed included:

- Overstocking of vaccines
- Improper storage of vaccines in the fridge. E.g., all vaccines are stored in one container or plastic
- No proper conditioning of the ice packs before storage in the vaccine carrier
- Poor handling of vaccine vials during immunization, e.g., from vaccine carrier to refrigerator and vice versa, or vaccine administration
- Poor documentation in the registers (child health register book, vaccine stock record book)
- Poor monitoring of vaccine temperature – temperature chart not regularly plotted.
- Lack of monitoring and feedback from the cold chain officer on the usage/supplies/changes/updates.
- Use of wrong syringes due to poor bundling of supplies
- Use of multi-dose vaccines even when there is only one child to vaccinate, which leads to vaccine wastage.
- Failure to store left-over vaccines in the fridge after child welfare clinic (CWC) sessions or satellite/outreach clinics – non-adherence to the Multi-Dose Vial Policy (MDVP)
- Health worker careless practices [handling/administration of vaccines – broken vials, underdose]
- Health workers' reluctance to conduct satellite/outreach clinics
- Delays in cleaning up of vaccine refrigerators – vaccine labels peel off, making identification difficult.
- Storage of food and drinks in the vaccine refrigerators

It was observed that all participant groups across the four provinces identified similar health worker practices that contribute to vaccine wastage, in addition to structural barriers. Some of the individual and structural barriers mentioned by the participants that hinder effective vaccine management included; transportation challenges for vaccines delivery to the clinics, limited availability of vaccine cold chain supplies e.g. vaccine carriers, thermometers, and icepacks, frequent breakdown of vaccine refrigerators, cloudy weather limiting the functionality of solar refrigerators, varied staff knowledge and understanding of effective vaccine management guidelines, limited cold chain maintenance expertise, and poor communication among staff. Identified health worker behavioral and practice barriers include health workers not reading guidelines and contingency plans probably because there are too many to read, health worker laxity in performing simple tasks like twice-daily temperature recording or returning unused vaccine vials to the refrigerator, are some of the major poor vaccine management practices contributing to higher vaccine wastage at the health facility or clinic levels. Besides, poor vaccine bundling and not documenting vaccine doses administered are also contributing factors. Some of the statements by health workers below provided more detail:

"*P 1: I think there is something behind the laziness. Nurses work for many years, but they did not receive anything like promotion or acceleration, that contribute to their laziness. There are a lot of contributing factors that contribute to their laziness. Maybe he/she wants to have further training but never had a chance for further training, even when attending such a workshop like this usually the regular staff will attend and others not*".

"P 1: Poor knowledge on vaccine storage, and so in the compartment of the fridges we should put vaccines separate as those exposed to the heat and those exposed to the cool system. There are times when nurses lack the knowledge and they store vaccines like measles which should be at the cool compartment but they store it up or front were exposed to heat."

" P 2: For the first point from all works of life effective communication is very essential especially in vaccine handling communication is very important. As we know that vaccine is a very expensive commodities therefore effective communication is very important. As well as standard monitoring procedures. Vaccines as nurses we must use standard monitoring procedures when handling it or else, we will spend a lot of money. So that is for the handling of vaccines. So, we are thinking that handling of vaccines is better if CCOs is the one handling the vaccines down right to the health facilities."

"P 3: Point two is procedures and guidelines need to be accessed and utilized for EVM at all levels of health facilities. All guidelines need to be available at all health facilities to uphold and maintain good and Effective Vaccine Management (EVM). These acts as guidelines and measures for nurses on a daily basis."

"P 4: Standard containers to store vaccines, standard vaccine carriers to fit 0.6 L ice pack. Currently, we are having problems with this the ice packs are too big so only two of them fit in the vaccine carrier. Therefore, we need a standard one to fit those sizes because it also contributes to the removal of labels of vaccines as the ice packs defrost that also brings wastages."

While exploring how to address vaccine wastage, the following strategies were suggested; ordering vaccines according to usage; daily job allocations including monitoring of fridge temperature; sharing job allocations with health workers a day before vaccination; using alarm clocks to remind nurses about temperature charting; posting reminder messages on proper vaccine storage and VVM, use of Early Expiry First Out (EEFO); separating heat-sensitive from cold-sensitive vaccines; printing and displaying ordering formula and schedule; taking personal responsibility for vaccine storage by all nurses; putting a notice on the fridge restricting nurses from storing foods and drinks in the vaccine fridge, and organizing in-house refresher training or continuing medical education sessions to enhance nurses skills in vaccine management.

Health worker norms

Participants discussed common health worker social norms that need to be addressed to achieve the set outcomes. Such norms included; the "wantok" system where health workers open and administer multi-dose vaccines to unscheduled clinic visits by friends and family without considering the possibility of high wastage; use of wrong procedures and equipment during vaccination such as using syringes to administer OPV vaccines; taking money from patients to open and administer multi-dose vaccines e.g measles-rubella; unnecessary opportunistic immunization especially during tournaments and festivals and misuse of acceptable wastages from the program perspective. Health workers expressed the feeling of not being sufficiently motivated or incentivized as such they revert to collecting tokens from clients. In the Solomon Islands, the "wantok" system is a strong community

Table 4
Suggested strategies by health workers to address identified negative norms.

Social Norms	Solutions
Favors to family & friends - "WANTOK" system	• Educate family and friends "Wantoks" to come at the right time, right place, and the right program, e.g., during CWC days. • Nurses to change their attitudes and do self-assessment on work performance. • Do away with the "wantok" system at the clinics. • Daily clinic announcements (mornings) • Integrate discussions in the radio programs on how the "wantok" system affects health service delivery.
Wrong procedures and use of wrong equipment	• Report and correct staff on the spot to avoid wastages. • Make stocks available on time. • Conduct regular stock-taking, e.g., bi-weekly.
Using staff status or seniority wrongly	• Nobody is above the law. • Treat all staff equally. • Senior staff should act as role models. • Staff to correct each other in case of wrong procedures or practices. • Have a suggestion box in place • In case senior staff is not following the right procedures, we shall use existing channels of communication to correct them.
Love for money, "Bribes."	• Say "NO" to money and instead explain to patients the right practices and immunization schedule. • Put up a "No bribes or gifts" poster in the clinics.
Events, e.g., sports tournaments	• If clients come from hard to reach, give opportunistic immunization. • Educate parents on the right immunization schedules.
Short cut system	• Print procedures and place them in different clinic areas. E.g., injection procedures in CWC/OPD. • Regular reminders, e.g., daily before the clinic start.
Social media	• Create simple rules at the workplace to control the misuse of phones during working hours.
Acceptable wastage misuse	• Educate parents/guardians on the importance of immunization • Consideration of those who need vaccination due to geographical distance or accessibility challenges. • Consider making bookings for parents who come from clinic catchment areas.
Late coming, "Solomon time."	• Use proper clock in the tool instead of a book record.

bond, and in this context, health workers feel a strong sense of responsibility to provide services without due regard to documented guidelines. After reviewing and discussing health worker norms that affect effective vaccine management, participants explored strategies they can use to address those negative norms that increase vaccine wastage as presented in Table 4 below.

Attitudes and perceptions towards vaccines

Besides the barriers mentioned above, health worker attitudes and perceptions towards vaccines were strongly positive as highlighted in participants' statements below referring great value-add of vaccines and the need to minimize wastage of vaccines. More so, participants emphasized these during the content creation sessions where participants developed draft materials to this effect.

"P 56: We must always think that vaccines are a lifesaver for the children."

"P 57: This is because of our attitude and we should know that vaccines are very expensive."

"P58: Yes, we should know that vaccines are cost and very expensive and also different people are buying for us so we must handle it properly. So we must remind all nurses that vaccines are cost."

3.3. Step 3

The focus of the third step was to continue teamwork and critical thinking linked to stimulating creativity concerning vaccine wastage communication. Participants were encouraged to use the explored practices and solutions from previous sessions to develop communication materials and tools that can help improve vaccine management and help reduce wastage. During this session, the facilitators placed more emphasis on developing communication tools and messages that will remind health workers to manage vaccines according to guidelines. Participants highlighted that while health workers may need refresher training in some procedures like proper reading of VVM, the majority of health workers know what to do (right procedures) but are just lazy to adhere to set protocols. Figs. 4 and 5 below shows what participants developed during the PAR sessions and the improved versions respectively.

Communication materials (poster concepts) developed by the groups

Several messages and suggested illustrations as poster and sticker concepts were produced during the sessions, which are aimed at reminding health workers to follow standard procedures in managing or handling vaccines. In discussing the final concepts with the larger group, it was observed that all the posters were appealing and would be informative. Participants were then asked to rank their poster creations in order of preference. The most preferred concepts for motivating health workers to address vaccine wastage, starting with the most preferred are listed below;

1. Daily temperature chart and alarm clock reminder
2. VVM and OPV color change posters
3. Steps for conditioning of icepacks poster
4. Power Outage contingency plan poster
5. Food restriction in the vaccine fridge poster
6. Color reminder cards
7. Vaccine ordering steps
8. Clinic program template

Potentials for peer support and activities

Participants were asked how they could continue to stimulate improved vaccine management culture. Some of the points raised included speaking to other health workers who did not have a chance to participate in the PAR sessions, organizing weekly in-house sessions to address critical issues about vaccines, discouraging the 'wantok' system in case family and friends call in for 'opportunistic' immunization; they suggested providing advice on child welfare days or planned outreaches. Participants also promised to activate suggestion boxes and encourage patients to write their suggestions or concerns and drop them in the box for action.

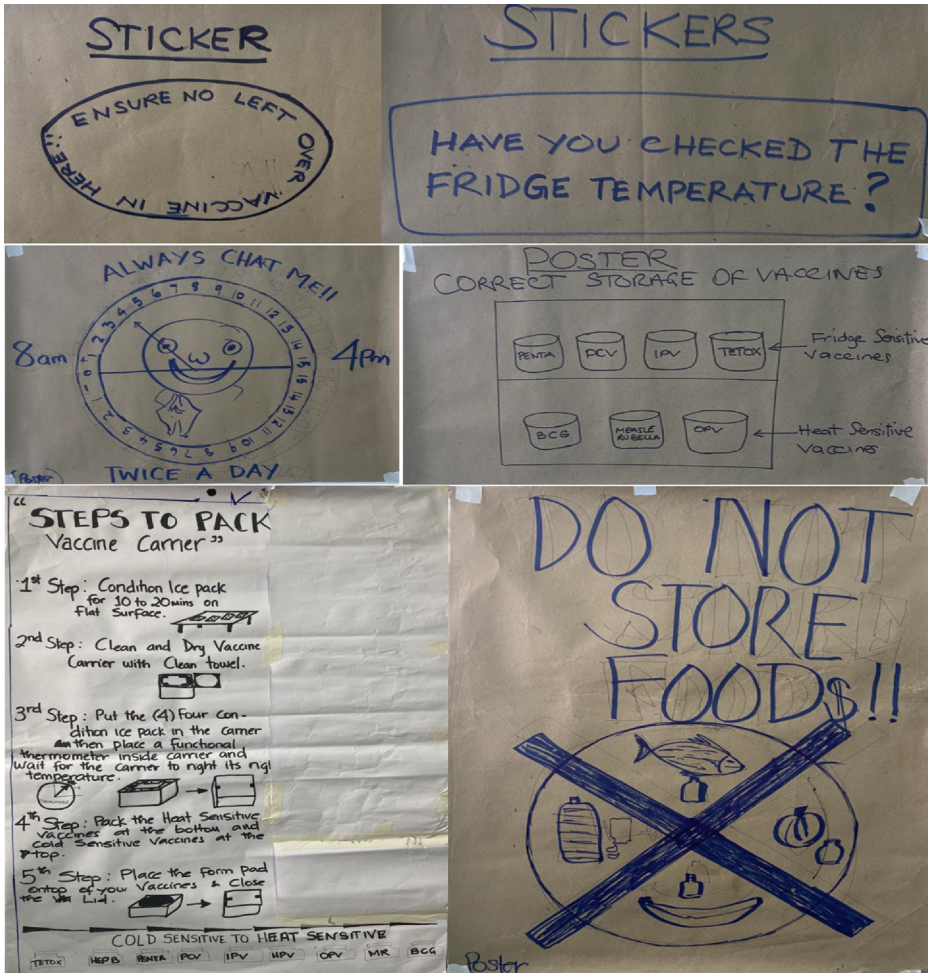

Fig. 4. *Some of the Poster concepts developed by the Participants during the PAR sessions* [These posters are some of the initial rough health worker illustrations of how best to present the message for behavior change communication to happen in the clinics for effective vaccine management]

Opportunities for integration

Regarding the integration of some of the concepts into social mobilization processes, it was agreed that clinics would integrate messages into on-going daily radio programs in the form of announcements, e.g., for immunization satellite clinic programs. In rounding off the discussions, there was further exploration of other possibilities of integration of child health service messages into on-going programs and how community members can be involved in holding health workers accountable.

Motivators

While health workers have developed and contextualized their communication materials to enhance proper vaccine handling and management, issues regarding health worker motivation were also discussed with health workers making suggestions on areas to get them better motivated for their work. Commendations, awards, promotion, and regular supervisory visits by superiors are some of the suggestions from the health workers. Further to the discussions on current practices and possible solutions, we also discussed how health workers could be motivated to do their work diligently and follow the right procedures to the book. We discovered that health workers do not feel motivated enough. When asked to suggest ways of motivating them, they came up with the following;

"P3: Send them for further training, like send them to Solomon Islands national university (SINU)".

"P 8: Availability of resources, temperature charts, vaccines, equipment, and others. If this is available at the clinic, it will also motivate us"

"P9: if we assure that everything is there, that will motivate the staff to do their work".

4. Discussions

This is the first study that explores health worker knowledge, motivation, ability to act and norms on effective vaccine management through participatory action research, and using the social-ecological model (SEM) as a guiding framework. This was necessitated due to the persistent failure of numerous health worker trainings alone to address or help resolve identified vaccine management issues. There is an increasing use of participatory action research (PAR) in healthcare, especially in the 21st century [13,14]. The action media approach, which has its roots in PAR, comprises of series of participatory research sessions guided by a standardized methodology that has been validated in wider settings [16]. Health workers from the four provinces of the Solomon Islands were able to participate and use their thoughts and deep insights to develop practical solutions that could help improve vaccine management and reduce wastages. The findings of this study cut across the different levels of the social-ecological model (SEM) ranging from the individual barriers, perceptions, and attitudes impacting on effective vaccine management through interpersonal,

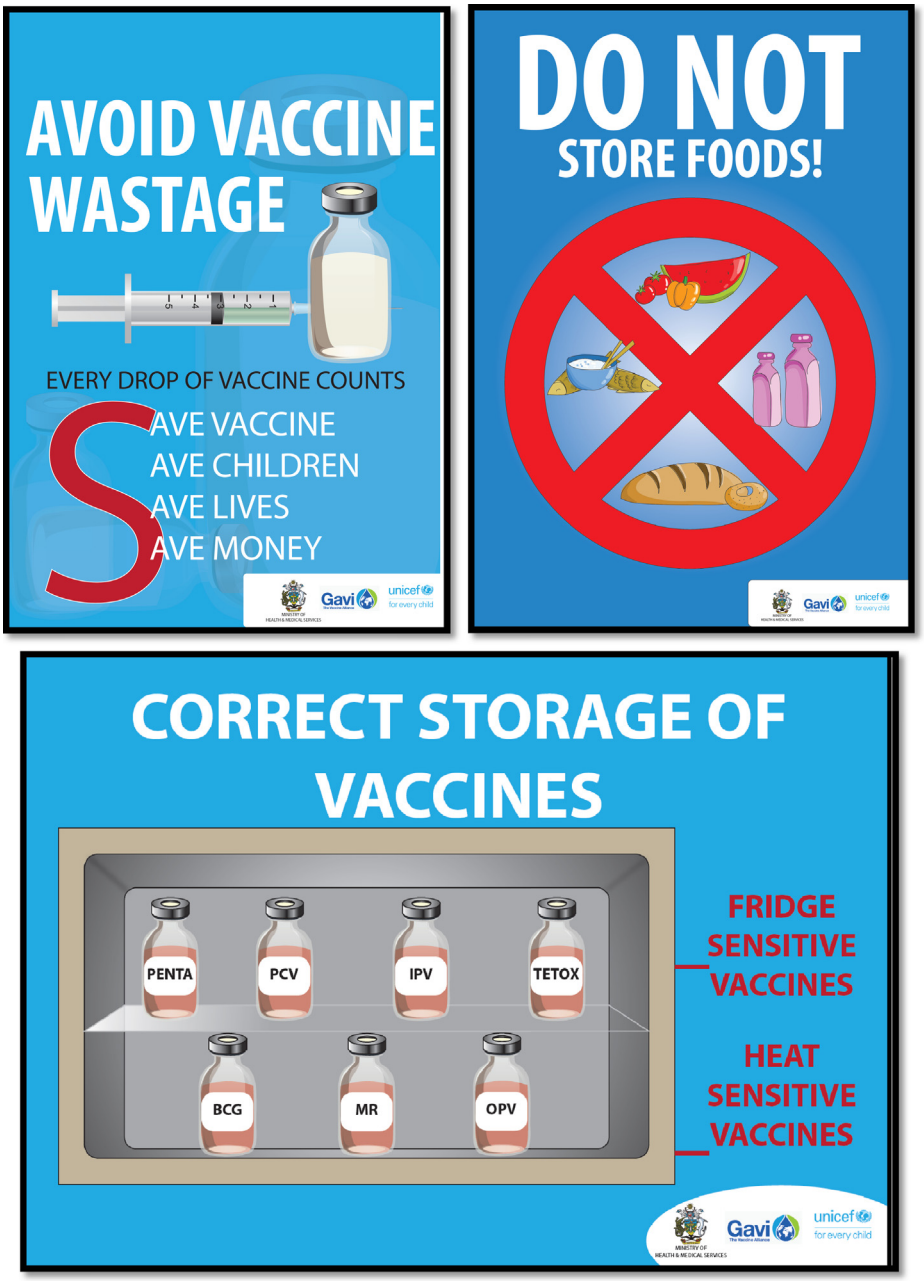

Fig. 5. *Some of the developed concepts now enhanced communication material* [These posters are the revised versions of the initial rough health worker illustrations of how best to present the message for behavior change communication to happen in the clinics for effective vaccine management]

organizational, community, and policy level factors. Health worker knowledge, motivation, ability to act, and norms, which are considered as cross-cutting factors in the SEM were demonstrated to play a significant role in effective vaccine management. Through a process of self-reflection and self-identified solutions, health workers articulated the most plausible solutions which if be applied at the personal, organization, and policy levels, can improve vaccine management and reduce wastage in the Solomon Islands. Most of the findings associated with poor vaccine management are consistent with findings from other countries or similar assessments in the Solomon Islands [2,3,11,12,20].

It was noted that health workers possess a fair amount of the required knowledge on vaccine management as per national and global guidelines. They demonstrated awareness of how to use both active and passive cold chain equipment, being aware of the temperature monitoring requirements in the immunization supply chain, and basic cold chain maintenance [21]. Although a continuous refresher will be needed to reinforce this knowledge, skills, and understanding. These should in turn motivate attitudinal changes leading to strict adherence to guidelines and recommendations. It is recognized that a high level of technical skills, expertise, and responsibility are required in vaccine handling and management, which cannot be achieved by mere didactic learning alone [20].

Furthermore, lack of health worker motivation was found to be a critical barrier for effective vaccine management. Participants cited examples where they are not provided the opportunity to attend workshops, or even getting acknowledged for the hard work they do at the health facilities. Most participants would like to be positively influenced by their seniors which doesn't seem to happen. This is a cross-cutting issue impacting all levels of the SEM. The requisite national and provincial policies need to make adequate provisions for staff motivation to do their work, the community and

the respective health facility heads and staff do have a role to ensure every health worker is motivated to do his or her job rightly.

Many structural barriers do exist and require attention if EVM challenges are to be fully addressed. Some of the challenges highlighted included distribution, cold chain equipment issues, and maintenance. Through the Gavi funded and UNICEF managed Cold Chian Equipment Optimization Platform (CCEOP), which is an innovative joint funding mechanism to strengthen the immunization supply chain in the country, Solomon Islands more recently benefited from cold chain capacity expansion, the introduction of more efficient cold chain equipment models and a sustainable maintenance plan. With these concurrent interventions addressing both the structural and behavioral barriers, vaccine management is expected to improve significantly.

While most vaccine management challenges identified were universal, there were unique ones identified that were either not considered prior, or not considered to affect vaccine management and wastage reduction in the Solomon Islands. An example is the "wantok" system, which can be described as a social network of people in Melanesia linked by either common language, common kinship, common belief, or common geography [22]. This is a personal-interpersonal factor built on an expectation of the clan on one hand, and obligation by the health worker on the other hand. It is interesting to see how this social network could impact vaccine wastage through a complex array of interplays. Such social networks are deep-rooted and probably have become norms and not amenable to training and refresher training of health workers. Depending on the context, such peculiar or unique attributes hampering effective vaccine management could be identified and solutions proffered by the health workers who are an integral part of the community.

With guidance, health workers were able to prioritize key concepts that could assist them in improving vaccine management. Numerous studies have cited regular and proper temperature charting as one of the key vaccine management practices that are not being adhered to [23,24,25,26]. The second and third top priorities as selected by the health workers were Vaccine Vial Monitors (VVM), OPV vaccine color change, and ice-packs conditioning. A systematic review of the availability and use of VVM in LMIC showed an overall high knowledge about VVM and its impact on vaccine potency [27]. While health workers in this study identified high VVM knowledge, they also consider it among the top three priorities, which should be addressed through SBCC to help reduce vaccine wastage.

Although this study focuses on health worker practices and behaviors as facilitators of vaccine wastage, it does not fail to recognize that social behavior change communication (SBCC) is a piece of the pie of interventions needed to improve vaccine management together with other routine methods such training and supportive supervision. However, in this study, other structural and health worker motivational issues were identified, which if addressed could result in significant improvements in vaccine management practices across health facilities. Some of the interesting structural issues identified included some vaccines having the same color lid (Penta + HepB), which is confusing to some health workers as well as the limited supply of thermometers and charts.

Overall our findings represent an important foundation for initial communication approaches and products, which can be expanded upon through further engagements with health workers during supportive supervision visits and refresher trainings. It helped identify issues that were never identified before, and workable solutions proffered by health workers themselves.

5. Conclusion

The participatory sessions with frontline health workers and cold chain officers were designed to support the development of communication strategies and materials that can help reduce vaccine wastage throughout the Solomon Islands. Through self-reflection, participants identified critical negative social norms and practices that impede effective vaccine management. Participants also suggested and committed to employing strategic approaches in addressing vaccine wastage. The Ministry of Health and Medical Services, UNICEF, and other partners should follow up with health workers and monitor progress through the national and provincial structures for better outcomes. Products will be finalized and distributed to all clinics, and subsequently, monitor performance to ascertain its effectiveness and contribution towards improved vaccine management practices. We encourage immunization programs to explore the use of participatory action report in addressing vaccine management bottlenecks.

5.1. Study limitations

There are a few limitations to this approach that should be noted. First, participants were not randomly selected but rather purposively selected due to their varying roles or involvement in the vaccine management chain. This implies that we cannot generalize the findings across geographical regions. Secondly, we could not have equal numbers of participants with similar functional roles in vaccine management; hence we ended up with more registered nurses than cold chain/pharmacy officers. Thirdly, due to limited resources, we could not conduct sessions in all provinces, although the four selected provinces are the biggest in the Solomon Islands, accounting for a combined majority of the country population.

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Availability of data and materials

This study relied on primary data, and the findings were based on analyses of the primary data collected.

Authors' contributions

ID and JS conceived the original idea for the study, involved in the design of the study, facilitation of sessions, analysis and interpretation of data, drafting of the manuscript. JA contributed to the design of the study, mobilized health workers for sessions, and contributed to transcript development. All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

Disclaimer

The contents and opinions expressed herein are those of the authors interpreting findings from the study and in no way reflect the views of their affiliated organizations.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A

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Collaborating partners:

Health Promoters, EPI Coordinators, and Child Health Officers from Malaita, Western, Guadalcanal provinces, and Honiara City Council.

Disclaimer:

The contents and opinions expressed herein are the responsibility of the authors and do not necessarily reflect the views of their affiliated organizations.

Acknowledgments:

We gratefully acknowledge the time taken by health workers and coordinators of the participatory sessions in all the four provinces.

Participants from Malaita:

Kerelee Riimana; Ovina Defoana; Chrisma Happy; Lovelyn Watelai; Nicodemus K; Donald Joe; Isac Mal; Nester Rara Houmola; James Oata; Joseph Odofia; John Pamlan; Esther Hooma; Rachel P; Ronley Maena; Greenter Fosala; John Mark

Participants from Western Province:

Lorrain Ladomea; Ken Norton; Gideon Pada; Steven Baju; Fiona Unusu; Bensley Bam; Daisy Katovai; Thelmah Rapo; Ireen Sipakana; Gweneth Napthalai; Narvin Sonta; Fred Nego; Titus Moatakapu; Francis Tatapu

Participants from Honiara City Council:

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Participants from Guadalcanal Province:

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Data Transcribers:

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Appendix B

Session	Activity
Day 1: Session 1	**Ground Rules:** • **Participatory sharing and learning process.** • **Important to commit to attending all sessions, avoid distractions such as cellphones.Logistics:** • **(perdiems, transport refund, meals, and refreshments)Time: Start time: 9:00am (NOT SOLOMON TIME), end time: 4:00 pm** • **Respect for all participants,** • **Free and equal contribution by all participants,** • **No right or wrong responses and the importance of confidentiality.** **The introduction game :(For all participants, and facilitators):** • **Choose a partner and sit together in the room** • **Before we learn about our partner, we are going to draw their face** • **You need to draw the face on the paper provided. Do not be concerned if you cannot draw well** • **When you are finished, give your drawing to your partner, and they will write their name on the drawing.** • **They should tell you their name, what they do if they are married if they have children and one thing that is unusual about themselves.** • **We will then come together as a group and introduce our partner.** **Group work:** • **What are the current health worker's social norms/practices/behaviors that lead to vaccine wastage?** • **Suggest solutions to the identified social norms/practices/behaviors**
Tea break:	
Day 1: Session 2	**Group presentations: Plenary session** • **Group presentations on health worker's social norms/ practices that lead to vaccine wastage and suggested solutions.** • **Group 1&2 : social norms/beliefs/practices that affect EVM & suggested solutions** • **Discussion by ALL.**
Lunch break:	
Day 1: Session 3	**Group discussion: *Motivators*** • **What do you think can motivate you to change the current negative norms and practices and adopt good practices and behavior?** • **What materials, job aids, tools can be useful for health workers and cold chain officers to support EVM and address vaccine wastage issues.**

Appendix B (*continued*)

Session	Activity
	• What formats? • In what area would you want to use it? • For what purpose is it going to be more useful? Wrap up the day with reflections on the sessions.

Session	Activity
Day 2: Session 1	Ground Rules: • Participatory sharing and learning process. • Important to commit to attending all sessions, avoid distractions such as cellphones.Logistics: • (perdiems, transport refund, meals, and refreshments)Time: Start time: 9:00am (NOT SOLOMON TIME), end time: 4:00 pm • Respect for all participants, • Free and equal contribution by all participants, • No right or wrong responses and the importance of confidentiality. • EVM protocols/guidelines/SOPs or other materials available in the room. • [5 min] • Participants stand in a circle. Energizer – from group • [20 min] • Participants share and review 'homework' questions from the previous day. • Group Presentations continue. Group discussion: • What do you think can motivate you to change the current negative norms and practices and adopt good practices and behavior? • What materials, job aids, tools can be useful for health workers and cold chain officers to support EVM and address vaccine wastage issues. • What formats? • In what area would you want to use it? • For what purpose is it going to be more useful?
Tea break:	
Day 2: Session 2	Group exercise: • [45 min] • Group exercise (2 groups, teams from the previous day): Design a material of your choice that you feel can be used by any health worker or cold chain officer to address vaccine wastage issues. • Note: this exercise provides a practical way to understand bringing together words and images to communicate.] • [15 min] • Participants report back and discuss, commenting on concepts liked and disliked.
Lunch break:	
Day 2: Session 3	Group presentations: *Material concepts* • Presentations of concepts and discussionsWrap up the day with reflections on the sessions.

Session	Activity
Day 3: Session 1	Ground Rules: • Participatory sharing and learning process. • Important to commit to attending all sessions, avoid distractions such as cellphones.Logistics: • (perdiems, transport refund, meals, and refreshments)Time: Start time: 9:00am (NOT SOLOMON TIME), end time: 4:00 pm • Respect for all participants, • Free and equal contribution by all participants, • No right or wrong responses and the importance of confidentiality. Session objectives: • Review of previous group work [concept development] • Concept testing • Wrap up and way-forward

(*continued on next page*)

Disclaimer (*continued*)

Session	Activity
	• Logistics and departure
Tea break:	
Day 3: Session 2	Concept Test (2 h) • Review concepts suggest modifications.Aspects of reviewing include: - • Overall visual impression, • Preferred Color, • Text elements • Potential mediums and placement.
Lunch break:	
Day 3: Session 3	Wrap up the day with reflections on the sessions.•Wrap up and way-forward•Logistics and departure

Appendix C

Appendix D. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.vaccine.2020.08.057.

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