Insights into vaccine hesitancy from systems thinking, Rwanda

Catherine Decouttere,a Stany Banzimana,b Pål Davidsen,c Carla Van Riet,a Corinne Vandermeulen,d Elizabeth Mason,a Mohammad S Jalali*a & Nico Vandeaeleb

Objective To investigate vaccine hesitancy leading to underimmunization and a measles outbreak in Rwanda and to develop a conceptual, community-level model of behavioural factors.

Methods Local immunization systems in two Rwandan communities (one recently experienced a measles outbreak) were explored using systems thinking, human-centred design and behavioural frameworks. Data were collected between 2018 and 2020 from: discussions with 11 vaccination service providers (i.e. hospital and health centre staff); interviews with 161 children’s caregivers at health centres; and nine validation interviews with health centre staff. Factors influencing vaccine hesitancy were categorized using the 3Cs framework: confidence, complacency and convenience. A conceptual model of vaccine hesitancy mechanisms with feedback loops was developed.

Findings A comparison of service providers’ and caregivers’ perspectives in both rural and peri-urban settings showed that similar factors strengthened vaccine uptake: (i) high trust in vaccines and service providers based on personal relationships with health centre staff; (ii) the connecting role of community health workers; and (iii) a strong sense of community. Factors identified as increasing vaccine hesitancy (e.g. service accessibility and inadequate follow-up) differed between service providers and caregivers and between settings. The conceptual model could be used to explain drivers of the recent measles outbreak and to guide interventions designed to increase vaccine uptake.

Conclusion The application of behavioural frameworks and systems thinking revealed vaccine hesitancy mechanisms in Rwandan communities that demonstrate the interrelationship between immunization services and caregivers’ vaccination behaviour. Confidence-building social structures and context-dependent challenges that affect vaccine uptake were also identified.

Introduction

Rwanda has a strong immunization system,1 a well-organized vaccine supply system and a well-functioning community health worker (CHW) programme.2 As a result, national immunization coverage rates are high and new vaccines are introduced swiftly.3,4 Nevertheless, some communities still face local disease outbreaks due to underimmunization. A major driver of underimmunization is vaccine hesitancy,5 which is defined by the World Health Organization (WHO) as “delay in acceptance or refusal of vaccination despite availability of vaccination services.”6 According to WHO, “vaccine hesitancy is complex and context specific, varying across time, place, and vaccines” and is one of the top 10 global health threats.7,8

Factors influencing vaccine hesitancy can be categorized using the 3Cs framework: (i) confidence; (ii) complacency; and (iii) convenience.9 As psychological, sociological and environmental drivers are paramount in instigating the behavioural changes required to address vaccine hesitancy,9,10 understanding the contextual relationships between vaccine hesitancy and socioeconomic determinants of health is crucial.11-16 Additionally, better understanding of vaccine hesitancy is needed to achieve the sustainable development goals, including universal access to quality vaccines.17 WHO’s Immunization Agenda 2030 highlights the importance of people-centredness for understanding the context-specific root causes of vaccine hesitancy and for co-designing solutions.18,19 However, the literature has major gaps on: (i) the analysis of human-centred design approaches; (ii) the relationship between beneficiaries and service delivery; and (iii) incorporating the interaction between hesitancy factors into policy and intervention design.6

For our study of underimmunization drivers in a low-income country, we focused on measles in Rwanda, because: (i) measles is highly contagious and there were indications of underimmunization; (ii) measles increases morbidity and mortality because it erases the immune memory and increases susceptibility to other infectious diseases;20,21 (iii) despite long-standing vaccination programmes, eradication has not been achieved globally according to the Global Measles and Rubella Strategic Plan 2012–2020;22 and (iv) the second measles vaccine dose was designated a performance tracer in the Immunization Agenda 2030.23 Moreover, the measles programme is monitored by WHO and the Rwandan government, which can provide data for future quantitative models.

In Rwanda, the measles vaccination programme has been quite successful: it achieved a national coverage rate above 85% for the second measles and rubella vaccine dose in 2015 and reached the target national coverage rate of 95% for the first dose in 2017.18,22 The first measles and rubella vaccine dose is administered 9 months after birth and, since 2015, the second dose is administered 15 months after birth. Despite these achievements, Rwanda still faces sporadic measles outbreaks (e.g. in Western Province in 2019).24

To inform policy design and to improve immunization levels, we aimed to study the mechanisms underlying vaccine hesitancy in Rwanda that contributed to local underimmunization for measles and a subsequent measles outbreak. We conducted an analysis of immunization service delivery...
in both a rural community and a peri-urban community between 2018 and 2020 and derived a conceptual model of vaccine hesitancy to assist in the design of sustainable interventions.

Methods

Our study design was based on WHO’s framework for health system building blocks and an already published immunization system diagram (Fig. 1).25,26 In analysing vaccine uptake, we applied systems thinking and behavioural frameworks such as the 3Cs framework and the behavioural drivers theory.4,5,26–31 First, we assessed how underimmunization was influenced by the three so-called immunization service flows: (i) the vaccinee (child); (ii) the healthcare workforce (nurse); and (iii) vaccine availability (vaccine). Second, we conducted in-depth interviews with health centre staff and collected secondary data (e.g. on vaccine orders, inventories and disease outbreaks). Based on our findings, we interviewed children’s caregivers to understand local factors influencing vaccine hesitancy. Then, we used the 3Cs framework to categorize factors reported by caregivers and health centre staff.4 Finally, we derived causal relationships between behavioural drivers, vaccination intent and vaccination uptake by analysing the vaccine hesitancy factors identified and present these relationships in causal loop diagrams. These diagrams are helpful for understanding complex systems and for developing interventions.29,30 All causal relationships in the causal loop diagrams and vaccine hesitancy factors were validated and explained during additional discussions with health centre staff.

Participants

We interviewed 11 vaccinators and staff of the Expanded Programme on Immunization at three district hospitals, six health centres in a peri-urban setting in Kicukiro District, Kigali Province and five health centres in a rural setting in Ngororero District, Western Province. Additional details are available from the data repository.32 At the community level, we interviewed caregivers at two health centres: one in rural Ramba in Ngororero District, where there was a measles outbreak in 2019, and one in Gahanga in the Kicukiro District. After a measles outbreak in July 2019, one of the Ramba health centre’s outreach posts became the Sovu health centre to be closer to people in the catchment area. Although these two locations share the same climate, epidemiological characteristics and health systems, they have different geographical and socioeconomic characteristics (Table 1). We attended two vaccination sessions at health centres and one outreach vaccination session in both communities. Each caregiver present was invited to participate in the study (i.e. a convenience sample) by having a face-to-face interview in or near the session waiting room. After the purpose of the research was explained, 161 caregivers participated: they were predominantly female and included both experienced mothers and mothers of firstborns.
Data collection and analysis

In-depth discussions were conducted with staff at the 11 health centres (data repository) between September 2018 and November 2019 by three senior researchers and between December 2019 and February 2020 by one researcher. Discussions lasted 60 to 120 minutes and followed a topic guide (more details available in the data repository). Four researchers analysed data in field notes and photographed documents.

After one day’s training, six Rwandan data collectors conducted semistructured interviews with caregivers in November 2020 (data repository). Conversations lasting 7 to 12 minutes were held in Kinyarwanda, translated into English by the interviewer and later discussed with a supervisor and the research team to reach a consensus on interpretation. Then, two researchers analysed factors associated with vaccine hesitancy using Excel (Microsoft Corporation, Redmond, United States of America) and four researchers classified these factors. One researcher held additional discussions with health centre staff between April and December 2020 to validate the findings (data repository).

Three researchers used the main underlying mechanisms of vaccine hesitancy identified by the analysis to construct causal loop diagrams, which illustrate the interconnections between different factors and show feedback loops. The feedback loops can be either reinforcing (i.e. cause change in the same direction) or balancing (i.e. cause change in the opposite direction). The study was approved by the Rwanda National Ethics Committee (No. 195/RNEC/2019) and is reported according to consolidated criteria for reporting qualitative research.

Results

During data collection at the 11 health centres, we found no evidence of vaccine stock-outs in 2018 or 2019. Moreover, there were no human capacity limitations that resulted in immunization services being unavailable and national immunization coverage rates were above 90%. However, measles outbreaks occurred because of a lack of timely immunization. The suspected cause was reluctant vaccine uptake rather than limited vaccine availability.

Vaccine hesitancy

Service providers’ perspective

Interviews with Expanded Programme on Immunization staff at the Ramba and Sovu health centres, the Gaahanga health centre and nine neighbouring health centres revealed contextual and behavioural factors that contributed to vaccine hesitancy. These factors were categorized according to the 3Cs framework (i.e. confidence, complacency and convenience) using a determinants matrix (Table 2; available at https://www.who.int/publications/journals/bulletin/).

Vaccination service providers reported that confidence is increased by trust in immunization service delivery and that a good relationship between caregivers and both nurses and CHWs is key. However, the time health centre staff could spend with each caregiver and the resulting quality of care were affected by an increased workload due to high peri-urban immigration rates of up to 10% per year, paperwork and other responsibilities.

We found that complacency was successfully reduced by: (i) organizing 6-monthly mother-and-child health weeks; (ii) regular community meetings (umuganda and w’ababyeyi or mothers’ evenings); (iii) educational sessions before vaccination sessions; and (iv) individual contacts between CHWs and caregivers. However, in rural settings, mothers tended to deprioritize or forget immunization of older children because of other tasks and because they had little contact with health centres in the 6-month interval between the first and second measles and rubella vaccine doses. This factor increased complacency and, combined with low disease surveillance in Sovu (which led to un-detected measles cases), contributed to the 2019 measles outbreak. CHWs were regarded as playing a crucial role in connecting mothers to antenatal care and vaccination services. However, concerns were raised about the sustainability of CHW programmes.

With regard to convenience, the availability of immunization services

Table 1. Characteristics of two participating communities, study of vaccine hesitancy, Rwanda, 2018–2020

| Characteristic            | Ramba and Sovu* | Community |
|--------------------------|-----------------|-----------|
| Geographical context     | Rural community, hilly and remote landscape, limited road infrastructure and long distances to the health centre (i.e. more than 5 km or 2 hours travel time) | Per-urban community with relatively short distances to the health centre (i.e. less than 5 km or 2 hours travel time) |
| Socioeconomic context    | 22% of the population live in extreme poverty, and many men are employed in coltan mining | 9% of the population live in extreme poverty, and the affordability of transport is less problematic than in Ramba or Sovu |
| Location of local district hospital | Kabaya, Ngororoero District, Western Province | Masaka, Kicukiro District, city of Kigali |
| Population               | 64 000 (50% Ramba health centre and 50% Sovu health centre) | 67 000 |
| Weekly vaccination sessions at fixed locations or outreach posts | 2–4 at the Ramba health centre and 1–3 at the Sovu health centre (since 1 January 2020) | 1–2 (fewer outreach services due to shorter distances and more affordable transport) |
| Measles outbreak since 2018 | July 2019 in the Sovu catchment area | None |
| Migration                | No significant in or out migration | Increasing number of people settling in the area as they flee Kigali’s city centre where property prices are continuously increasing. Some clients visited health centres other than the one they were assigned to |

* After a measles outbreak in July 2019 at one of the Ramba health centre’s outreach posts, that post became the Sovu health centre to be closer to people in the catchment area.
Table 3. Caregivers’ comments on factors affecting vaccine hesitancy, Rwanda, 2018–2020

| Factor affecting vaccine hesitancya | Selected comments on factor by caregiversb,c,d,e | Rural health centres in Ramba and Suvo (n = 74) | Peri-urban health centre in Gahanga (n = 87) |
|-------------------------------------|--------------------------------------------------|-----------------------------------------------|--------------------------------------------|
| Confidence                          |                                                  |                                               | Positive: hesitancy about vaccines from specific manufacturers was not observed or suspected as no respondent mentioned the name of a vaccine—they referred to the vaccine according to the time at which it needed to be administered (e.g. “vaccine for 2.5 months”) |
| Trust in the effectiveness and safety of vaccines and in their manufacturers | Positive: (i) all respondents were happy to vaccinate their child as it protects the child against disease (of course, selection bias must be considered here as caregivers at vaccination sessions were interviewed. However, respondents mentioned that, “nothing could stop me to come to the service” or called the services “a blessing,” which showed strong motivation and ample confidence); and (ii) hesitancy about vaccines from specific manufacturers was not observed or suspected as no respondent mentioned the name of a vaccine—they referred to the vaccine according to the time at which it needed to be administered (e.g. “vaccine for 2.5 months”) | Positive: hesitancy about vaccines from specific manufacturers was not observed or suspected as no respondent mentioned the name of a vaccine—they referred to the vaccine according to the time at which it needed to be administered (e.g. “vaccine for 2.5 months”) | Positive: hesitancy about vaccines from specific manufacturers was not observed or suspected as no respondent mentioned the name of a vaccine—they referred to the vaccine according to the time at which it needed to be administered (e.g. “vaccine for 2.5 months”) |
| Trust in, and personal experience of, the health system and health professionals | Positive: (i) health centre staff (mostly nurses and vaccinators) are seen as a good source of information (40 respondents) and are contacted to discuss questions on vaccination (29 respondents); and (ii) respondents mentioned that getting information on other health topics (e.g. stunting) during the vaccination sessions and receiving *shisha kibondo* (i.e. porridge) were additional benefits | Positive: health centre staff (mostly nurses and vaccinators) most frequently mentioned as a source of information (69 respondents) and as a contact for discussing questions (55 respondents). Negative: some mothers had negative experiences when their child was not given the vaccine (e.g. they were sent home because they were late or because a multidose vial could not be opened) or they received a fine (e.g. for being late, not having their child vaccinated or not re-engaging with the vaccination system after a home delivery) | Positive: health centre staff (mostly nurses and vaccinators) most frequently mentioned as a source of information (69 respondents) and as a contact for discussing questions (55 respondents). Negative: some mothers had negative experiences when their child was not given the vaccine (e.g. they were sent home because they were late or because a multidose vial could not be opened) or they received a fine (e.g. for being late, not having their child vaccinated or not re-engaging with the vaccination system after a home delivery) |

Complacency

| Communication and media environment | Neutral: (i) radio is still a source of information on vaccination services (31 respondents); (ii) government campaign materials (e.g. flyers) were mentioned less often as a source of information (2 respondents); and (iii) interestingly, the vaccination card was also explicitly mentioned as a source of information (10 respondents) | Neutral: (i) radio is still a source of information on vaccination services (35 respondents); and (ii) government campaign materials (e.g. flyers) were frequently mentioned as a source of information (20 respondents), as were vaccination cards (6 respondents) | Neutral: (i) radio is still a source of information on vaccination services (35 respondents); and (ii) government campaign materials (e.g. flyers) were frequently mentioned as a source of information (20 respondents), as were vaccination cards (6 respondents) |
| Influential leaders, immunization programme gatekeepers and vaccination lobbies | Positive: no caregivers mentioned local leaders as a negative influence (one respondent reported how the local leader goes around the village with a loudspeaker to give information about vaccination and other activities) | None | None |
| Historical influences | Positive: measles outbreak in 2019 increased the number of visible cases | Positive: some respondents mentioned that being sick was a barrier (4 respondents) but others (4 respondents) said that, even when they are sick, there are people in the community (e.g. husband, CHW or neighbour) who can take the child for vaccination (i.e. community engagement). Negative: (i) caregivers mentioned that a few caregivers do not bring their children to the vaccination session, describing them as “careless” (3 respondents) or “busy with life” (1 respondent); and (ii) family conflict (1 respondent) and children who cry during the night after vaccination (1 respondent) were mentioned as reasons for not attending vaccination | Positive: some respondents mentioned that being sick was a barrier (4 respondents) but others (4 respondents) said that, even when they are sick, there are people in the community (e.g. husband, CHW or neighbour) who can take the child for vaccination (i.e. community engagement). Negative: (i) caregivers mentioned that a few caregivers do not bring their children to the vaccination session, describing them as “careless” (3 respondents) or “busy with life” (1 respondent); and (ii) family conflict (1 respondent) and children who cry during the night after vaccination (1 respondent) were mentioned as reasons for not attending vaccination |
| Religion, culture, gender and socioeconomic factors | Positive: respondents mentioned that, when they are sick, there are people in the community (e.g. husband, CHW or neighbour) who can take the child for vaccination (i.e. community engagement). Negative: (i) caregivers mentioned that a few caregivers do not bring their children to the vaccination session, describing them as “careless” (3 respondents) or “busy with life” (1 respondent); and (ii) family conflict (1 respondent) and children who cry during the night after vaccination (1 respondent) were mentioned as reasons for not attending vaccination | Positive: some respondents mentioned that being sick was a barrier (4 respondents) but others (4 respondents) said that, even when they are sick, there are people in the community (e.g. husband, CHW or neighbour) who can take the child for vaccination (i.e. community engagement). Negative: (i) caregivers mentioned that a few caregivers do not bring their children to the vaccination session, describing them as “careless” (3 respondents) or “busy with life” (1 respondent); and (ii) family conflict (1 respondent) and children who cry during the night after vaccination (1 respondent) were mentioned as reasons for not attending vaccination | Positive: some respondents mentioned that being sick was a barrier (4 respondents) but others (4 respondents) said that, even when they are sick, there are people in the community (e.g. husband, CHW or neighbour) who can take the child for vaccination (i.e. community engagement). Negative: (i) caregivers mentioned that a few caregivers do not bring their children to the vaccination session, describing them as “careless” (3 respondents) or “busy with life” (1 respondent); and (ii) family conflict (1 respondent) and children who cry during the night after vaccination (1 respondent) were mentioned as reasons for not attending vaccination |

(continues...
| Factor affecting vaccine hesitancy | Rural health centres in Ramba and Suvu (n = 74) | Per-urban health centre in Gahanga (n = 87) |
|-----------------------------------|-----------------------------------------------|------------------------------------------|
| Knowledge and awareness           | Positive: (i) CHWs were mentioned most frequently as a source of information on vaccination services (67 respondents) and as a contact for asking questions about services (70 respondents), but they were also thought to be over-worked and under-paid, and (ii) CHW follow-up visits were highly valued to ensure that children were vaccinated and healthy. | Positive: (i) CHWs were mentioned most frequently as a source of information on vaccination services (45 respondents) and as a contact for asking questions about services (44 respondents). |
|                                  | Positive: (i) CHW follow-up was explicitly mentioned as having improved over the years (3 respondents) – “In the past, you could even not finish all vaccines/appointments and there was no one to follow-up on you, but if you do not come as per your appointment in these days, a CHW will reach out to you and ask why you did not go for vaccination and advise you on how to catch up”; and (ii) other community members (mostly other mothers and neighbours) were frequently mentioned as sources of information on vaccination services (16 respondents). | Positive: (i) respondents mentioned that community members were aware of the importance of vaccination because of community mobilization, involving, for example, CHWs and campaigns; and (ii) CHWs were mentioned as the second most frequent source of information on vaccination services (25 respondents) and as a contact for asking questions about these services (22 respondents). |
|                                  | Positive: (i) the need for disease prevention was strengthened by knowledge of cases of illness or death due to vaccine-preventable diseases (25 respondents); and (ii) all respondents were highly motivated to attend vaccination sessions by their desire to prevent disease or ensure their children will grow up to be healthy. | Positive: in addition to their role in preventing disease, vaccines were trusted because they had had no negative effects so far (7 respondents). Negative: (i) fear of adverse effects following immunization (2 respondents); and (ii) most respondents did not know of cases of illness or death due to vaccine-preventable diseases – known cases (7 respondents) were mostly polio or measles, often in older people. |
| Immunization as a social norm     | Positive: respondents who did not know of any cases of illness or death due to vaccine-preventable diseases (38 respondents) mentioned that the community and their parents knew the importance of vaccines for protecting children; (ii) vaccination seemed to be standard (e.g. “every kid is vaccinated in the community”); and (iii) vaccination was frequently endorsed by community members, such as friends and family. | Positive: vaccination sessions were easy to reach and travel times were short but caregivers can be sent away if they do not have an appointment, are late, or if the desired vaccine or antigen is not offered that day, for example, to save multidose vials. Negative: caregivers were sometimes not informed and were not aware of the child’s immunization status. Negative: heavy rainfall makes it difficult to attend (1,5 respondents). |
| Convenience                        | Positive: (i) only one mother mentioned the availability of vaccines as an explicit reason for coming to the vaccination session; and (ii) stock-outs were not mentioned as a barrier. Negative: negative: (i) it was difficult to attend the vaccination sessions due to the child’s age (4 respondents), and (ii) reward for being fully vaccinated was not provided. | Positive: caregivers were paid for their time, and outreach services were seen as providing a convenient way to access vaccination services. Negative: cost of transport is a barrier (3 respondents). |
| Availability of the immunization service (including vaccine availability) | Positive: (i) only one mother mentioned the availability of vaccines at an open and accessible location as an explicit reason for coming to the vaccination session; and (ii) stock-outs were not mentioned as a barrier. Negative: (i) more financial support requested (4 respondents); and (ii) reward for being fully vaccinated was not provided. | Positive: vaccination sessions were easy to reach and travel times were short but caregivers can be sent away if they do not have an appointment, are late, or if the desired vaccine or antigen is not offered that day, for example, to save multidose vials. Negative: caregivers were sometimes not informed and were not aware of the child’s immunization status. Negative: heavy rainfall makes it difficult to attend (1,5 respondents). |
| Affordability of the immunization service | Positive: (i) only one mother mentioned the availability of vaccines at an open and accessible location as an explicit reason for coming to the vaccination session; and (ii) stock-outs were not mentioned as a barrier. Negative: (i) more financial support requested (4 respondents); and (ii) reward for being fully vaccinated was not provided. | Positive: caregivers were paid for their time, and outreach services were seen as providing a convenient way to access vaccination services. Negative: cost of transport is a barrier (3 respondents). |
| Geographical accessibility         | Positive: vaccination sessions were easy to reach and travel times were short but caregivers can be sent away if they do not have an appointment, are late, or if the desired vaccine or antigen is not offered that day, for example, to save multidose vials. Negative: caregivers were sometimes not informed and were not aware of the child’s immunization status. Negative: heavy rainfall makes it difficult to attend (1,5 respondents). | Positive: vaccination sessions were easy to reach and travel times were short but caregivers can be sent away if they do not have an appointment, are late, or if the desired vaccine or antigen is not offered that day, for example, to save multidose vials. Negative: caregivers were sometimes not informed and were not aware of the child’s immunization status. Negative: heavy rainfall makes it difficult to attend (1,5 respondents). |
| Ability to understand (i.e. language and health literacy) | Positive: (i) one mother mentioned the children could not read or write and asked family members or neighbours to read the data on the vaccination card. | Positive: (i) children could understand the need for vaccination and were not afraid of needles. Negative: (i) one mother mentioned that the child did not understand the importance of vaccination, which made it difficult for the mother to give consent. Negative: (i) some mothers still mentioned that the child was afraid of needles. |
Factors affecting vaccine hesitancy mechanisms, Rwanda

Catherine Decouttere et al.

Factors associated with vaccine hesitancy were reported in interviews with caregivers in Ramba, Sovu and Gahanga were also categorized using the 3Cs framework (Table 3). With regard to confidence, caregivers reported no concerns about vaccine quality and trusted vaccines. Additionally, in rural settings, trust was reported to stem from respect for providers, including nurses and CHWs. CHWs were more often reported as a source of information in rural than in peri-urban settings. The impact of government information campaigns seemed greater in peri-urban settings.

With regard to complacency, caregivers did not mention misinformation on social media in either setting. Carelessness and forgetting were considered to be the main reasons for underimmunization, particularly when mothers had older children, more tasks and different priorities.

Factors affecting convenience varied considerably between rural and peri-urban settings, with differences in travel time, place and cultural context.
distances and waiting times. In the rainy season, travelling safely with young children was complicated in rural areas and immunization was delayed; some people relied completely on outreach services.

Comparing perspectives

Both service providers and caregivers largely agreed on the strengths of the vaccination programme but identified different challenges (Box 1, based on Table 2 and Table 3). By considering caregivers’ insights, immunization providers were able to obtain a broader perspective on their services, which in turn provided a basis for designing future interventions. For example, the introduction of an efficient digital data management system could help tackle the multiple challenges perceived by immunization providers while maintaining an appointment system well regarded by caregivers.

Causal loop diagrams

The causal relationships between the main factors affecting vaccine hesitancy identified in interviews with vaccination service providers and caregivers are illustrated in three causal loop diagrams in Fig. 2 (available at https://www.who.int/publications/journals/bulletin/), for confidence, complacency and convenience, respectively. Fig. 3, which is a composite of these three diagrams, indicates that vaccine uptake is governed by three key factors: (i) trust in vaccination; (ii) community engagement; and (iii) access to vaccination. As vaccine uptake evolves, six feedback loops are activated (Fig. 3): three balancing B loops and three reinforcing R loops that can increase or decrease trust, engagement or access. These loops illustrate the dynamic nature of the system. The same factors and loops were identified in both rural and peri-urban settings but their relative impact on vaccination uptake differed. For example, in rural settings, access to vaccinations was reduced by a lack of outreach services and information campaigns, whereas, in peri-urban settings, workload pressure on the immunization system had a negative impact on trust in vaccination.

To maintain measles vaccination coverage at the desired level of over 95%, behaviour that increases vaccine uptake, as indicated by loops in the causal loop diagram (Fig. 3), must be actively promoted by health interventions. For example, government-led information and vaccination campaigns, community advocacy and direct communication from CHWs during home visits all regularly boost the perceived benefit of vaccination and community engagement. The disruption caused by the coronavirus disease 2019 (COVID-19) pandemic affected the 3Cs: (i) convenience was diminished because vaccination sessions were smaller and less accessible; (ii) confidence was reduced by heightened pressure on the system and fear of infection at the health centre; and (iii) complacency was increased by less contact between CHWs and caregivers.

The composite causal loop diagram can also be used to illustrate the circumstances that led to the 2019 measles outbreak in Sovu (Fig. 4). First, community and caregiver engagement with the second measles and rubella immunization dose for children aged 15 months was low because mothers had other priorities, perceived their children as stronger due to being older, or were not aware of the second dose. Second, in the absence of outreach services, health centres did not know which children were underimmunized. Therefore, the need for an additional immunization campaign or outreach services was not recognized. The resulting outbreak triggered a new immunization campaign and further investigations. Eventually, a new health centre was established in the affected area, which reduced the previously underimmunized population’s dependency on both outreach services and immunization campaigns. The ongoing development of digital data management systems at health centres will support this change. In addition, CHWs can help bridge the gap between caregivers and the health system and can assist in surveillance.

Box 1. Vaccination service providers’ and caregivers’ perspectives on the strengths of, and challenges to, the measles vaccination programme in rural and peri-urban Rwanda, 2018–2020

| Strengths | All interviewees: |
|-----------|------------------|
| • CHWs provide information, mobilize caregivers and follow up vaccines; | |
| • health centre staff provide information; | |
| • confidence in vaccination is high; | |
| • there is an intrinsic motivation to improve health; and | |
| • community support. | |
| Vaccination service providers: | |
| • health ministry committed to supporting CHWs and mother-and-child health weeks. | |
| Caregivers: | |
| • vaccination cards; | |
| • information provided by radio; | |
| • high service quality; and | |
| • appointments system. | |

| Challenges | All interviewees: |
|------------|------------------|
| • outreach services needed for poor and hard-to-reach families. | |
| Vaccination service providers: | |
| • high staff turnover and workload and need for training; | |
| • tracing of vaccine defaulters inefficient; | |
| • outreach services for measles and rubella vaccination inadequate; and | |
| • mothers missing the second measles and rubella vaccine dose for their children. | |
| Caregivers: | |
| • difficult vaccination access in the rainy season; | |
| • long distances to health centres; and | |
| • long waiting times. | |

CHW: community health worker.
Fig. 3. Composite causal loop diagram of factors affecting vaccine hesitancy, Rwanda, 2018–2020

Fig. 4. Composite causal loop diagram of factors affecting vaccine hesitancy during a measles outbreak, Rwanda, 2019

Notes: This diagram is the composite of the three causal loop diagrams in Fig. 2. Factors affecting vaccine hesitancy were categorized using the 3Cs framework as related to confidence, complacency or convenience. The R loops are reinforcing feedback loops that cause change in the same direction and the B loops are balancing loops that cause change in the opposite direction.

Notes: The measles outbreak occurred in the catchment area of the Ramba health centre in 2019. This diagram is an adaptation of the causal loop diagram in Fig. 3. Factors affecting vaccine hesitancy were categorized using the 3Cs framework as related to confidence, complacency or convenience. The R loops are reinforcing feedback loops that cause change in the same direction and the B loops are balancing loops that cause change in the opposite direction.
Discussion

Our analysis of factors influencing vaccine hesitancy in Rwanda offers several insights. For example, trust in vaccination and social cohesion are factors that can be leveraged in various settings. However, the differences we identified between rural and peri-urban settings in the ease of travel indicate that solutions for vaccine hesitancy and vaccine policy design are dependent on the setting, even for the same vaccine in the same country. Both vaccination service providers (i.e. Expanded Programme on Immunization staff and CHWs) and caregivers thought that the accessibility of vaccination sessions and the quality of the immunization service were important influences behind underimmunization. However, the insights we obtained from service providers and caregivers revealed they had differing perspectives, which provided an opportunity for collective learning and for increasing vaccine uptake.

Some service delivery policies had unintended consequences. For instance, according to national guidelines, multidose vaccine vials must be used at fixed sites rather than at both outreach posts and fixed sites to reduce wastage. This policy may increase vaccine hesitancy by reducing access to, or the convenience of, vaccination for people dependent on outreach services. Moreover, in some places in Rwanda, there used to be a financial penalty if a child was not registered with the vaccine system at birth. Consequently, families whose children were born at home were often deterred from visiting health centres due to misinformation that the penalty still existed. Conversely, this lasting fear of a financial penalty may incentivize some pregnant mothers to engage with vaccination.

Our findings illustrate the crucial role of community engagement in building system resilience. Causal loops can be strengthened or weakened by external elements, such as interventions made in response to a measles outbreak. For instance, communication within communities can be leveraged by prolonging CHW programmes, thereby enhancing social cohesion. In contrast, the COVID-19 pandemic induced the perception that health centre visits were unsafe. This perception, combined with the temporary cancellation of community awareness activities and educational sessions at health centres, resulted in immunization being delayed until mid-August 2020. The speed at which vaccine uptake was restored after the disruption showed the resilience of the system.35,36

As outreach services are a cornerstone of measles immunization programmes in some populations, their sustainability will affect future immunization programmes. The efficiency of outreach could be increased by focusing efforts on hard-to-reach populations or by establishing temporary outreach posts during the rainy season. Dependency on outreach services could be reduced by opening new health-care delivery points or by providing physical or financial support to enable caregivers to travel to health centres, both of which would enhance the sustainability of the immunization system.

Our study of two settings in Rwanda revealed leverage points that cut across several factors influencing vaccine hesitancy (i.e. one specific intervention can impact multiple loops within the immunization system). For example, we found that the connecting role of CHWs was pivotal and that they could function as a high-potential leverage point because they have a direct impact on two feedback loops in Fig. 3: the balancing convenience loop (i.e. identifying the need for outreach and vaccination campaigns) and the reinforcing complacency loop (i.e. increasing awareness of the benefits of vaccination through home visits).37 Furthermore, the digitization of local immunization data, such as the immunization status of the population (irrespective of the point of vaccination), could guide targeted and timely preventive interventions (e.g. catch-up vaccinations in the child’s second year of life), assist in campaign planning and help trace defaulters. Nevertheless, the factors affecting vaccine hesitancy can change over time (e.g. in response to vaccine-hesitant social media influencers).37

Our study has limitations. First, the presence of a well-functioning vaccination delivery system in Rwanda may make it more difficult to generalize our findings. Second, although we carefully selected the study settings, they were limited in number and our findings relate to only rural and peri-urban communities. More research is needed on urban and other settings. Third, we were not able to interview caregivers who are not present at vaccination sessions. However, interviewees were asked about the motivations of caregivers who missed sessions. Similarly, we interviewed only CHWs and other vaccination service providers who spoke on behalf of their teams, which may have introduced bias. Finally, the COVID-19 pandemic complicated fieldwork.

In addition to overcoming these limitations, future research could build on our insights and causal loop diagrams to develop a human-centred, collaborative approach to identifying leverage points that could be used to design sustainable interventions for minimizing vaccine hesitancy. Moreover, our systems thinking approach and factors influencing hesitancy could be integrated with initiatives like the Vaccine Confidence Project,38 which contains a tool for mapping confidence globally.12,14,39,40

Acknowledgements

We thank Christine Lee, Alan Zhang, the Expanded Programme on Immunization team in Rwanda and all participants in workshops, interviews and field visits.

Funding: This work was funded by GSK through the GSK research chair on the redesign of health care supply chains in developing countries to increase access-to-medicines, KU Leuven.

Competing interests: Stany Banzimana received a PhD scholarship funded by GSK. Catherine Decouttere was funded through a GSK research chair at KU Leuven. Corinne Vandermeulen was a principal investigator on a study for GSK unrelated to this research for which KU Leuven received a grant.
从系统思维深入了解“疫苗犹豫” 卢旺达

目的 调查导致卢旺达免疫不足和麻疹爆发的“疫苗犹豫”；并开发一个社区层面的概念性行为因素模型。

方法 采用系统思维、以人为本的设计理念和行为框架，探索了卢旺达两个社区(其中一个地区最近经历了麻疹爆发)的当地免疫系统。收集的2018年至2020年数据来自：与卫生中心工作人员的个人关系对疫苗和服务提供者的高度信任；(ii) 社区卫生工作者所起到的纽带作用；(iii) 强烈的社区意识。被确定为增加“疫苗犹豫”的因素(例如服务的可及性和后续随访不足)在不同的环境中以及在不同的服务提供者和看护人员之间有所不同。该概念模型可用于解释近麻疹爆发的驱动因素，并指导提高疫苗接种率的干预措施。

结论 行为框架和系统思维的应用揭示了卢旺达社区的“疫苗犹豫”机制，证明了免疫服务与护理人员的疫苗接种行为之间的相互关系。还确定了营造信心的社会结构和不同环境下影响疫苗接种的挑战。

Résumé

Analyse de l’hésitation vaccinale à l’aide de la pensée systémique au Rwanda

Objectif Analyser l’hésitation vaccinale menant à une immunisation insuffisante et à une épidémie de rougeole au Rwanda, mais aussi développer un modèle conceptuel de facteurs comportementaux à l’échelle communautaire.

Méthodes Nous avons examiné les systèmes d’immunisation locaux dans deux communautés rwandaises (une ayant récemment subi une épidémie de rougeole) en utilisant la pensée systémique, une approche centrée sur l’humain et des cadres comportementaux. Les données ont été récoltées entre 2018 et 2020 auprès de plusieurs sources: les discussions avec 11 prestataires de services liés à la vaccination (hôpitaux et centres médicaux); des entretiens avec 161 aides-soignants du département pédiatrique dans divers centres médicaux; et enfin, neuf entretiens de validation avec le personnel des centres médicaux. Nous avons classé les facteurs conditionnant l’hésitation vaccinale conformément à la règle des 3C: confiance (confidence), sous-estimation (complacency) et commodité (convenience). Un modèle conceptuel des mécanismes d’hésitation vaccinale assorti de boucles de rétroaction a également été élaboré.

Résultats D’après une comparaison entre les perspectives des prestataires de services et aides-soignants, tant en milieu rural que périurbain, des facteurs similaires renforcent la prise vaccinale: (i) un degré de confiance élevé envers les vaccins et les prestataires de services, fondé sur les relations entretenues avec le personnel des centres médicaux; (ii) le rôle d’intermédiaire joué par les agents de santé communautaires; et enfin, (iii) un fort sentiment d’appartenance à la collectivité. Les facteurs qui ont tendance à accroître l’hésitation vaccinale (parmi lesquels figurent l’accessibilité aux services et l’absence de suivi adéquat) varient entre prestataires de services et aides-soignants, ainsi que selon les milieux. Le modèle conceptuel pourrait servir à
identifier les moteurs de la récente épidémie de rougeole, et orienter les actions destinées à améliorer la prise vaccinale. **Conclusion** L’application des cadres comportementaux et de la pensée systémique ont révélé les mécanismes qui sous-tendent l’hésitation vaccinale au sein des communautés rwandaises, et qui prouvent la corrélation entre les services d’immunisation et le comportement des aides-soignants en la matière. Nous avons également découvert des structures sociales de restauration de la confiance ainsi que des défis qui, en fonction du contexte, ont un impact sur la prise vaccinale.

---

**References**

1. Robson J, Bao J, Wang A, McAlister H, Uwizihiwe J-P, Sanyozoga F, et al. Making sense of Rwanda’s remarkable vaccine coverage success. Int J Healthc. 2020;6(1):56. doi: http://dx.doi.org/10.5430/ijh.v6n1p56.

2. Condo J, Mugeni C, Naughton B, Hall K, Tuaizon MA, Omwega A, et al. Rwanda’s evolving community health worker system: a qualitative assessment of client and provider perspectives. Hum Resour Health. 2014 Dec 13;12(1):71. doi: http://dx.doi.org/10.1186/1478-4491-12-71 PMID: 25495237.
3. Seruyange E, Gahutu JH, Mambbo Muvunyi C, Umwima ZG, Gatiera M, Twagiramugabe T, et al. Measles seroprevalence, outbreaks, and vaccine coverage in Rwanda: a retrospective analysis of district level data. (Lond). 2016 Nov–Dec;48(11–12):800–7. doi: http://dx.doi.org/10.1080/23744235.2016.1201722 PMID: 27386985

4. Gatera M, Bhatt S, Ngabo F, Utamuliza M, Sibomana H, Karema C, et al. Successive introduction of four new vaccines in Rwanda: high coverage and rapid scale up of Rwanda's expanded immunization program from 2009 to 2013. Vaccine. 2016 Jun 17;34(29):5420–6. doi: http://dx.doi.org/10.1016/j.vaccine.2015.11.057 PMID: 26704259

5. Salmon DA, Dudley MZ, Glanz JM, Omer SB. Vaccine hesitancy: causes, consequences, and a call to action. Vaccine. 2015 Nov 27;33 Suppl 4:666–71. doi: http://dx.doi.org/10.1016/j.vaccine.2015.09.035 PMID: 26615171

6. MacDonald NE; SAGE Working Group on Vaccine Hesitancy. Vaccine hesitancy: definition, scope and determinants. Vaccine. 2015 Aug 14;33(34):4161–4. doi: http://dx.doi.org/10.1016/j.vaccine.2015.04.036 PMID: 25896383

7. Ten threats to global health in 2019. Geneva: World Health Organization; 2020. Available from: https://www.who.int/news-room/spotlight/ten-threats-to-global-health-in-2019 [cited 2020 Dec 9].

8. Report of the Sage Working Group on vaccine hesitancy. Geneva: World Health Organization; 2014. Available from: https://www.who.int/immunization/sage/meetings/2014/october/1_Report_WORKING_GROUP_vaccine_hesitancy_final.pdf [cited 2021 Sep 7].

9. Pettit V. The behavioural drivers model: a conceptual framework for social and behaviour change programming. Amman: United Nations Children's Fund, 2019. Available from: https://www.unicef.org/media/5586/file/The_Behavioural_Drivers_Model.pdf [cited 2021 Sep 7].

10. Brewer NT, Chapman GB, Rothman AJ, Leask J, Kempe A. Increasing vaccination: putting psychological science into action. Psychol Sci Public Interest. 2017 Dec;18(3):149–207. doi: http://dx.doi.org/10.1177/1529100617733090 PMID: 29605595

11. Dubé E, Gagnon D, Nickels E, Jeram S, Schuster M. Mapping vaccine hesitancy – country-specific characteristics of a global phenomenon. Vaccine. 2014 Nov 20;32(49):6649–54. doi: http://dx.doi.org/10.1016/j.vaccine.2014.09.039 PMID: 25280436

12. Hansen LA, Hartert TK, Cornia G, Colventragh S, Fumagalli L. The evidence for vaccine hesitancy: a systematic review of observational studies. JAMA Pediatr. 2017;171(10):989–97. doi: http://dx.doi.org/10.1001/jamapediatrics.2017.1925 PMID: 28911588

13. Decouttere CJA, Vandaelle N, De Boeck B, Banzimana S. A systems-based framework for immunisation system design: six loops, three flows, two paradigms [preprint]. medRxiv. 2021 July 30.2021.07.19.21260775. doi: http://dx.doi.org/10.1101/2021.07.19.21260775

14. Luke DA, Stamatakis KA. Systems science methods in public health: dynamics, networks, and agents. Annu Rev Public Health. 2012 Apr;33(1):357–76. doi: http://dx.doi.org/10.1146/annurev-publichealth-031511-011222 PMID: 22224885

15. Homostrans. Community-based system dynamics. New York: Springer, 2014. doi: http://dx.doi.org/10.1007/978-1-4614-7863-0

16. Ghoshal S, Pai S, Marr T. Understanding the messages and motivation of vaccine hesitant or refusing social media influencers. Vaccine. 2021 Jan 8;39(2):350–6. doi: http://dx.doi.org/10.1016/j.vaccine.2020.11.058 PMID: 33280856

17. Decouttere C. Revealing vaccine hesitancy mechanisms using systems thinking: supplementary data. London: Figgisame; 2021. doi: http://dx.doi.org/10.6084/m9.figshare.16578242.v1

18. Poverty mapping report 2013–2014. Kigali: National Institute of Statistics of Rwanda, 2017. Available from: https://www.stats.gov.rw/publication/poverty-mapping-report-2013-2014 [cited 2021 Sep 7].

19. Tong A, Sainsbury P, Craig J. Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups. Int J Qual Health Care. 2007 Dec;19(6):439–47. doi: http://dx.doi.org/10.1093/intqhc/mzm042 PMID: 17872937

20. Decouttere C. Revealing vaccine hesitancy mechanisms using systems thinking and implementation science to improve immunisation system performance. Int J Infect Dis. 2020 Sep;98:161–5. doi: http://dx.doi.org/10.1016/j.ijid.2020.06.072 PMID: 32592908

21. Leader AE, Burke-Garcia A, Massey PM, Roark JB. Understanding the messages and motivation of vaccine hesitant or refusing social media influencers. Vaccine. 2021 Jan 8;39(2):350–6. doi: http://dx.doi.org/10.1016/j.vaccine.2020.11.058 PMID: 33280856

22. The Confidence Project [internet]. London: Vaccine Confidence Project; 2021. Available from: https://www.vaccineconfidence.org/ [cited 2021 Sep 7].

23. Lane S, MacDonald NE, Marti M, Dumordal L. Vaccine hesitancy around vaccines and vaccination from a global perspective: a systematic review of published literature, 2007–2012. Vaccine. 2016 Jun 17;34(29):3420–6. doi: http://dx.doi.org/10.1016/j.vaccine.2015.04.037 PMID: 25896384

24. WHO vaccine-preventable diseases: monitoring system. 2020 global summary. WHO UNICEF estimates time series for Rwanda. Geneva: World Health Organization; 2020. Available from: https://apps.who.int/immunization_monitoring/globalsummary/estimates?c=RWA [cited 2020 Dec 9].

25. WHO vaccine-preventable diseases: monitoring system. 2020 global summary. Incidence time series for Rwanda. Geneva: World Health Organization; 2020. Available from: https://www.who.int/immunization_monitoring/globalsummary/incidence?c=RWA [cited 2020 Dec 28].

26. Decouttere CJA, Vandenelle N, De Boeck B, Banzimana S. A systems-based framework for immunisation system design: six loops, three flows, two paradigms [preprint]. medRxiv. 2021 July 30.2021.07.19.21260775. doi: http://dx.doi.org/10.1101/2021.07.19.21260775

27. Adamu AA, Jalo RI, Habonimana D, Wiysonge CS. COVID-19 and routine vaccination: putting psychological science into action. Psychol Sci Public Interest. 2017 Dec;18(3):149–207. doi: http://dx.doi.org/10.1177/1529100617733090 PMID: 29611455

28. Luke DA, Stamatakis KA. Systems science methods in public health: dynamics, networks, and agents. Annu Rev Public Health. 2012 Apr;33(1):357–76. doi: http://dx.doi.org/10.1146/annurev-publichealth-031511-011222 PMID: 22224885

29. Homvard PS. Community-based system dynamics. New York: Springer, 2014. doi: http://dx.doi.org/10.1007/978-1-4614-7863-0
| Factor affecting vaccine hesitancy | Selected comments on factor by service providersa | Location of service providers’ facilitiesb,c,d |
|-----------------------------------|-------------------------------------------------|------------------------------------------------|
| **Confidence**                    |                                                 | District hospitals (n = 3) Rural health centres (n = 5) Peri-urban health centres (n = 6) |
| Trust in the effectiveness and safety of vaccines and in their manufacturers | Positive: “vaccine hesitancy, in the narrowest sense of trust in the vaccine, is not an issue in Rwanda” | Positive: (i) high level of trust in vaccination, and (ii) one vaccinator saw very few adolescent girls who feared the HPV vaccine and had questions about rumours that the vaccine would prevent pregnancy | Positive: high level of trust in vaccination |
| Trust in, and personal experience of, the health system and health professionals | Neutral: CHWs are highly respected (more in rural than urban areas). Negative: (i) high turnover of staff at health centres; (ii) insufficient training of vaccinators to upgrade their knowledge; (iii) insufficient induction for newly recruited nurses and vaccinators; (iv) shortage of vaccinators and nurses; and (v) high vaccinator workload due to monitoring and paperwork | Neutral: CHWs are highly respected (more in rural than urban areas). Negative: (i) high turnover of staff at health centres; (ii) insufficient training of vaccinators to upgrade their knowledge; (iii) insufficient induction for newly recruited nurses and vaccinators; (iv) shortage of vaccinators and nurses; and (v) high vaccinator workload due to monitoring and paperwork | Neutral: some caregivers travel far to see an experienced nurse they know rather than attend a new, closer health centre. Negative: (i) shortage of staff at health centres because nurses prefer to get jobs at a hospital or in cities rather than in rural areas; (ii) insufficient training of nurses in vaccine management; and (iii) during lockdown, people were afraid of getting infected with SARS-CoV-2 when they visited health centres |
| **Complacency**                   |                                                 | District hospitals (n = 3) Rural health centres (n = 5) Peri-urban health centres (n = 6) |
| Communication and media environment | Positive: mother-and-child health weeks held every 6 months | Positive: CHW role increased during lockdown (when they were the only channel for information) | None |
| Influential leaders, immunization programme gatekeepers and vaccination lobbies | Positive: health minister supportive of immunization programme, CHWs and mother-and-child health weeks | None | None |
| Religion, culture, gender and socioeconomic factors | None | Positive: umuganda (i.e. monthly Rwandan voluntary community meetings where local issues and updates are discussed). Negative: (i) umuganda was temporarily suspended during lockdown; (ii) “mothers are forgetting about the second measles dose”; (iii) “attention of mother reduces when child grows up”; (iv) mothers have other priorities and postpone visits to health centres and vaccination sessions, resulting in late immunization; (iv) “forgetting is not about being unwilling, but the mother couldn’t go because of other priorities”; (v) “I would go tomorrow or next week”; (vi) sometimes the vaccination session is the same day when salaries for 15 days are given out, so caregivers cannot attend that day; and (vii) poor families work long hours away from home, leaving little time for children | None |

(continues . .)
### Vaccine hesitancy mechanisms, Rwanda

Catherine Decouttere et al.

**Factor affecting vaccine hesitancy**

| Location of service providers’ facilities |
|------------------------------------------|
| District hospitals (n = 3) | Rural health centres (n = 5) | Peri-urban health centres (n = 6) |

#### Knowledge and awareness

Positive: (i) CHWs have an important role in building community engagement; (ii) CHWs are trusted and highly respected by the community; and (iii) home visits by CHWs at childbirth connects mothers with health centres and informs them about immunization.

Negative: CHW service may not be sustainable because replacing ageing CHWs depends on the motivation of the next generation.

#### Perceived risks and benefits

None

Positive: “people are intrinsically motivated for vaccination”

Negative: (i) the perceived risk of disease was low because cases in the community remained undetected; and (ii) “measles cases were not detected, not diagnosed, and not medically treated”

#### Immunization as a social norm

Positive: immunization discussed as part of monthly community meetings (umuganda) and mothers’ evenings (w’ababyei).

Negative: None

#### Convenience

**Availability of the immunization service**

Positive: CHWs’ role in raising awareness in the community and organizing outreach services.

Negative: higher vaccine wastage at outreach posts.

Positive: (i) poor families were not able to afford travel to health centres and relied on outreach services; (ii) measles and rubella vaccine available only at health centres and not at outreach posts; (iii) BCG vaccine available only when 10 children were waiting; (iv) mothers that gave birth sometimes needed to come back to the health centre within 2 weeks for the BCG vaccine; and (v) vaccines in multidose vials (e.g. the measles and rubella vaccine) were offered once a week whereas other vaccines were offered daily.

Negative: vaccines in multidose vials (e.g. the measles and rubella vaccine) were offered only once a week whereas other vaccines were offered daily.

#### Affordability of the immunization service

None

Positive: “poverty is not a reason for not coming, everybody comes: poor and less poor.”

Negative: “usually, living conditions are a driver for dropping out.”

#### Geographical accessibility

None

Positive: “short distance, people from different catchment areas and districts come here.”

Negative: restricted access to one health centre due to a landslide.

#### Ability to understand (i.e. language and health literacy)

Positive: appointment system with cards is well understood by caregivers.

Negative: misunderstanding of practical and organizational policies makes people feel unwelcome.

(continues . . .)
| Factor affecting vaccine hesitancy* | District hospitals (n = 3) | Rural health centres (n = 5) | Peri-urban health centres (n = 6) |
|--------------------------------------|---------------------------|-----------------------------|----------------------------------|
| Quality of the service (perceived or real) | None | Positive: (i) CHWs closely involved in outreach organization and in tracing vaccine defaulters; and (ii) fewer patients attended health centres during lockdown, leaving more time for each patient. Negative: (i) high nurse workload due to combining vaccination sessions at health centres and outreach posts with night shifts; (ii) increased number of children to be vaccinated in each session; (iii) one health centre did not function well in the past as it provided only fixed sessions and had no outreach for several years; and (iv) 73 children missed the second measles and rubella vaccine dose in 2018. | Positive: “splitting up the large catchment area led to better management. All vaccines are now offered every day, except the BCG vaccine.” Negative: (i) “sometimes the EPI nurse has a night shift the day before the session. Sometimes she cannot attend the session”; (ii) the population is increasing at 10–15% per annum but services cannot keep up; and (iii) experienced mothers saw a drop in service quality due to increased nurse workload as more programmes were decentralized to health centres and health posts (e.g. malaria, tuberculosis and HIV services and family planning). |
| Convenient time (including waiting time), place and cultural context | Negative: (i) missed opportunities to vaccinate because vaccination days were different in different health centres; and (ii) COVID-19 restrictions resulted in a lack of indoor waiting rooms, making it hard for caregivers and children | Positive: (i) providing nutrition services and family planning in addition to vaccination was received positively; and (ii) having vaccination sessions on market days encourages mothers to attend. Neutral: vaccination is the mother’s responsibility and she prefers to come to the health centre when there is a market nearby. Negative: problem with power backup at a health centre | Positive: providing nutrition services in addition to vaccination. Neutral: the day of the week is less important than whether it is raining. Negative: (i) with 40–50 people per session, waiting times can be up to 5 hours; (ii) 60–75 or even 100 children per session; and (iii) nurse wants to give BCG vaccine and measles and rubella vaccine on the same day but BCG vaccines take time as they require a new file and card to be made each time. |
| Design of vaccination programme, vaccination schedule and data management at health centres | Positive: the transition to a digital data management system will improve the functioning of vaccination sessions | Negative: (i) ‘defaulter tracing didn’t work well [due to paper-based data system and high workload] and people are lost to follow-up when they go to the neighbouring district’; and (ii) data management system does not show when people are dropping out | Positive: “Computers will be installed soon.” Negative: (i) identifying drop-outs using paper files is labour-intensive and requires the help of CHWs; (ii) “drop-outs are checked at the end of the month, reasons for dropping out are explored. They are usually living conditions, or when people move to another area”; (iii) calculating vaccine coverage is difficult because of the changing population in the catchment area; (iv) at the age of 9 months, children need to get the first measles and rubella vaccine dose at their own health centre to receive a mosquito net; and (v) “no free choice of health centre for measles and rubella.” |

BCG: bacillus Calmette–Guérin; CHW: community health worker; COVID-19: coronavirus disease 2019; EPI: Expanded Programme on Immunization; HIV: human immunodeficiency virus; HPV: human papillomavirus; SARS-CoV-2: severe acute respiratory syndrome coronavirus 2.

* Factors were categorized using the 3Cs framework as related to confidence, complacency or convenience.8

† Comments were classified as positive, neutral or negative with regard to their implications for vaccine uptake.

‡ Vaccinators and Expanded Programme on Immunization staff were interviewed.

§ Details of which interviewees made each comment are available from supplement 3 in the data repository.32
Fig. 2. Causal loop diagrams of factors affecting vaccine hesitancy, by factor category, Rwanda, 2018–2020

Notes: Factors affecting vaccine hesitancy were categorized using the 3Cs framework as related to confidence, complacency or convenience. The R loops are reinforcing feedback loops that cause change in the same direction and the B loops are balancing loops that cause change in the opposite direction.

For confidence, reinforcing factors represented by the R loop include: (i) respectful relationships with health centre staff and community health workers engenders trust in vaccine services; (ii) mothers overcome fear of being late for immunization when they know the nurse and feel welcome; (iii) multiple contacts between the caregiver and nurse increases trust; and (iv) an entry in the mother-and-child booklet indicating immunization has been completed is encouraging for both caregivers and their families. Balancing factors represented by the B loop include: (i) long waiting times; (ii) short contact times between nurse and caregiver, which give the nurse little time to explain vaccination (one reason was numerous administrative tasks and demands from other vaccination programmes); and (iii) suspension of educational sessions before vaccinations during the coronavirus disease 2019 pandemic.

For complacency, reinforcing factors represented by the R loop include: (i) a well-protected population experiences fewer cases of disease, which increases the perceived benefit of vaccination and community engagement. Balancing factors represented by the B loop include: (i) a decline in cases of disease lowers both awareness of the threat to young children and the perceived importance of vaccination; and (ii) caregivers worry less about their children's health as they grow up, which increases complacency and can lead some to deprioritize their vaccination appointments.

For convenience: reinforcing factors represented by the R loop include: (i) families that are healthy, literate and financially stable are more likely to understand their appointment schedule and can afford to travel to health centres to vaccinate their children. Balancing factors represented by the B loop include: (i) the risk of a disease outbreak is increased in poorly protected populations (which can be remedied by immunization campaigns and enhanced vaccination services, including outreach).