Rural COVID-19 Resilience and Risk Reduction Intervention in Western India: A Retrospective Evaluation

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Abstract

Background: Globally, especially in the lower middle-income countries (LMICs), rural populations had higher susceptibility to the negative impact of the Covid-19 pandemic due to lower levels of community awareness, poor hygiene, and lower health literacy accompanying pre-existing weak public health systems. Consequently, various community-based interventions were engineered in rural regions worldwide mitigate against the COVID-19 pandemic by empowering the people to mount both individual and collective public health responses against the pandemic. These interventions were predominantly driven through the principles of community engagement through dedicated village level volunteers that coordinated government and administrative action to enable the delivery of need-based assistance to the village communities. Furthermore, technology-based interventions through social media communication, short message texts, and pre-recorded voice calls were frequently utilized to improve community awareness and preparedness during the pandemic. However, till date, there is paucity of information on the effectiveness of any large-scale community intervention in controlling and mitigating the effect of the Covid-19 pandemic especially from the perspective of LMICs.

Objective: This retrospective impact evaluation study was conducted to evaluate the effect of a large-scale rural community-based intervention, the Covid Free Village Program (CFVP) on Covid-19 resilience and control in a rural population in India. Principles of village empowerment, volunteerism, community mobilization informed the intervention with techno-managerial support by a grassroot non-governmental organization.

Methods: The intervention period lasted from Aug 2021-Feb 2022 and the impact evaluation from April-May 2022. Data were collected from 3500 sample households from villages across intervention (Pune district) and comparison (Satara district) arms using two stage stratified random sampling through face-to-face interviews followed by developing a matched sample using propensity score matching methods.

Results: We did not observe any significant change in the overall Covid-19 vaccination coverage due to the implementation of the CFVP. Furthermore, the number of Covid-19 deaths in both the sampled populations were very low. However, participants in Pune compared to Satara had a significantly higher combined Covid-19 awareness index by 0.43 points (95% CI 0.29-0.58). Furthermore, the adherence to covid appropriate behaviors including handwashing was 23% (95% CI 3%-45%), and masking was 17% (0-38%) higher in Pune compared to Satara. The probability of the availability of routine medical services, continuing routine child immunization, routine antenatal services, and medicines for chronic diseases had significant higher odds in Pune compared to Satara. Furthermore, the probability of observing Covid-19 related stigma or discrimination in their locality was 68 percent lower (CI=0.133-0.191) in Pune compared to Satara.

Conclusions: The CFVP contributed to improved awareness and sustainability of Covid appropriate behaviours in a large population although without evidence of higher Covid-19 vaccination coverage or reduction in mortality, signifying potential applicability in future pandemic preparedness especially in resource constrained settings. Clinical Trial: Not Applicable

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Rural COVID-19 Resilience and Risk Reduction Intervention in Western India: A Retrospective Evaluation

Running Title

Impact evaluation to assess rural Covid resilience.

Authors

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ABSTRACT

Background

Globally, especially in the lower middle-income countries (LMICs), rural populations had higher susceptibility to the negative impact of the COVID-19 pandemic due to lower levels of community awareness, poor hygiene, and lower health literacy accompanying pre-existing weak public health systems. Consequently, various community-based interventions were engineered in rural regions worldwide mitigate against the COVID-19 pandemic by empowering the people to mount both individual and collective public health responses against the pandemic. However, till date, there is paucity of information on the effectiveness of any large-scale community intervention in controlling and mitigating the effect of the COVID-19 pandemic especially from the perspective of LMICs.

This retrospective impact evaluation study was conducted to evaluate the effect of a large-scale rural community-based intervention, the Covid Free Village Program (CFVP) on COVID-19 resilience and control in a rural population in Maharashtra state in Western India.

Methods

The intervention site were rural areas of Pune district where the CFVP was implemented from August 2021 to February 2022, while the adjoining district, Satara, represented the control district where the CFVS was implemented. Data were collected during April-May 2022 from 3500 sample households from villages across intervention and comparison arms using two stage stratified random sampling through face-to-face interviews followed by developing a matched sample using propensity score matching methods.

Results

The participants in Pune compared to Satara had a significantly higher combined COVID-19 awareness index by 0.43 points (95% CI 0.29-0.58). Furthermore, the adherence to covid appropriate behaviors including handwashing was 23% (95% CI 3%-45%), and masking was 17% (0-38%) higher in Pune compared to Satara. The probability of perception of COVID as a serious illness in

patients with heart disease was 22 percent (CI-1.036-1.439) higher in Pune compared to Satara. The awareness index of COVID-19 variants and preventive measures was also higher in Pune by 0.88 (CI=0.674-1.089) points. On subgroup analysis, when the highest household educational level was restricted to middle school, the awareness about COVID control program was also 0.69 (CI-0.36-1.021) points higher in Pune, while the awareness index of COVID-19 variants and preventive measures was higher by 0.45 (CI- 0.236-0.671) points.

We did not observe any significant change in the overall COVID-19 vaccination coverage due to the implementation of the CFVP. Furthermore, the number of COVID-19 deaths in both the sampled populations were very low. Furthermore, the probability of observing COVID-19 related stigma or discrimination in their locality was 68 percent lower (CI=0.133-0.191) in Pune compared to Satara.

Conclusions

The CFVP contributed to improved awareness and sustainability of Covid appropriate behaviours in a large population although without evidence of higher COVID-19 vaccination coverage or reduction in mortality, signifying potential applicability in future pandemic preparedness especially in resource constrained settings.

*Keywords***:** COVID-19; Community intervention; COVID-19 vaccination; Covid appropriate behaviour; Impact evaluation; Rural health

Introduction

The global health crisis caused by the COVID-19 pandemic affected communities worldwide with poverty and social inequity accentuating vulnerability to risk of infection and death particularly in lower-middle-income countries (LMICs) [1]. Within the developing world, rural populations had higher susceptibility to the negative impact of COVID-19 due to lower levels of community awareness, poor hygiene, and lower health literacy accompanying pre-existing weak public health systems [2,3]. A multi country analysis from Southeast Asia region observed high prevalence of suboptimal Covid appropriate practices [4]. Furthermore, the challenge of healthcare accessibility in these settings was exacerbated as a significant proportion of health facilities lacked routine service provision functionality either due to infrastructural deficits or due to the diversion of existing health resources for the COVID-19 pandemic management purposes [5]. In India, similar challenges were experienced in the rural countryside, which constitutes nearly 70% of the country's population. A study from the Southern Indian state of Karnataka reported high levels of stressors amongst village communities during the COVID-19 pandemic due to financial distress and perceived inadequacy of specific treatment availability for COVID-19 [7,8]. COVID-19 vaccination which was the mainstay of preventing severe COVID-19 disease and reduction of mortality was frequently lagging in rural areas compared with their urban counterparts due to factors such as reduced awareness, vaccine hesitancy, and difficult access to vaccination services [9]. Rural health systems, particularly in low- and middle-income countries (LMICs), were not equipped to handle the COVID-19 pandemic on a global scale. Additionally, national responses to the virus generally failed to adequately address the unique challenges faced by rural communities [10].

In the midst of escalating COVID-19 spread, various community-based interventions were engineered in rural areas across several LMICs to restrict the transmission of COVID-19 and enable and empower the people to mount an effective response against the disease transmission by adopting standard preventive measures [8-10]. These intervention methods were predominantly driven by the

principles of community engagement through dedicated village level volunteers that coordinated government and administrative action with the perceived village requirements to enable need-based assistance to the village communities [11]. Technical support was also significantly leveraged especially through digital communication via short message service texts and pre-recorded voice calls to improve COVID-19 related awareness in rural communities [12]. The effective application of social media platforms to improve awareness and behaviors that were protective against COVID-19 were reported by studies in Jordan and Bangladesh [13, 14].

There is emerging evidence suggestive of the nature of successful COVID-19 initiatives in rural areas being collaborative with local communities, sharing encouragement for multisectoral outlays, with engagement of local cultures and their leaders [10]. However, till date, there is paucity of information on the effectiveness of any large-scale community intervention in controlling and mitigating the effect of the COVID-19 pandemic especially from the perspective of LMICs. The present study was therefore conducted to assess the impact of a large-scale community intervention for promoting COVID-19 resilience in rural areas of Pune district in India.

Maharashtra state in India was severely affected by the COVID-19 pandemic especially in the aftermath of the peak of the second (Delta) wave of the COVID-19 pandemic, in response to which, the state government launched a Covid-Free Village Scheme (CFVS) cum contest in June 2021 for empowerment of villagers in combating the COVID-19 pandemic, one of the largest in the world [15]. The scheme envisaged collective action for pandemic control through the creation of multiple village level groups known as village task force (VTF) within each Gram Panchyat (GP), which represents the local grassroots-governing institute at the level of villages in India. Each constituted VTF was entrusted with specific responsibilities towards mitigation and resilience to COVID-19 infection in all villages. Select non-government organizations (NGOs) in few districts were also entrusted with the responsibility for the planning and implementation of the CFVS in certain districts by providing technical and managerial support.

Pune district in Maharashtra reported nearly 1.1 million confirmed COVID-19 cases, with over 19,000 deaths until March 2022. Rural population in the district were particularly vulnerable since Pune, the seventh largest city in India recorded high burden of COVID-19 infection during the initial waves of the pandemic [16]. The CFVS scheme was implemented in the rural areas of Pune district from August 2021-March 2022 through support with a grassroots NGO (Bharatiya Jain Sangathana, BJS) that provided technical support and coordination with the district and village administration to fulfil community needs during the pandemic. Assessment of the CFVS scheme in Pune district would explain the usefulness of such large community-based interventions in controlling the COVID-19 pandemic and suggest the effect and applicability of the model in combating future pandemics and other endemic public health problems.

This impact evaluation was conducted to understand the difference in COVID-19 awareness, adherence to protective measures, vaccination coverage, morbidity and mortality, and associated factors in the in the CFVP (intervention) versus the CFVS (comparison) villages.

Methods

Study Settings

The intervention site were rural areas of Pune district where the CFVP was implemented from August 2021 to February 2022, while the adjoining district, Satara, represented the control district where the CFVS was implemented.

Satara was among the five districts which had the highest positivity rate in Maharashtra and the reported caseload was higher than the state average. As per the 2017-18 report of the Public Health Department of Maharashtra state, there were 66 Primary Health Centres (PHC and 353 sub-centres for 81.01% (24,33,363) of the rural population in Satara district. In comparison, Pune district was the worst affected during the pandemic and recorded the highest number of COVID-19 cases in the state. There were significant differences in the availability and accessibility of health facilities between

urban and rural areas. For 39.01% (3,678,226) rural population in Pune district, only 86 Primary Health Centres and 358 sub-centres were available across the district. Pune Zilla Parishad (ZP) collaborated with various NGOs and community organizations to implement COVID-19 control measures, including setting up vaccination centres, conducting testing drives, and providing healthcare.

The government of Maharashtra in its advisory recommended the launch of the Covid Free Village Scheme (CFVS) requiring the constitution of five VTFs in every village for conduct of household survey (VTF-1), functioning of isolation centre (VTF-2), arranging vehicle drivers for transporting patients for Covid testing and treatment (VTF-3), running a Covid Helpline (VTF-4), and promoting COVID-19 Vaccination (VTF-5). The CFVS scheme in Pune was supported by an NGO (BJS) that provided additional COVID-19 containment and resilience components towards the planning, implementation, and community mobilization especially the youth, which was operationally defined as the Covid Free Village Program (CFVP) to distinguish it from the CFVS that was implemented in Satara sans NGO involvement. Furthermore, the VTFs created as part of the CFVP differed from the CFVS by incorporating support for Covid awareness and behavior change in the rural population. CFVP VTFs included VTF 1 that focused on COVID appropriate behaviour (masking, hand washing, social distancing), VTF 2 on tracing, tracking, testing and treatment, VTF 3 was dedicated towards establishing COVID care centres and quarantine centres, VTF 4 on providing awareness and support to enrol for government schemes and VTF 5 was dedicated to work on COVID-19 vaccination. There was flexibility in the CFVP approach as the task forces were designed to be activated and responsive to ground level exigencies due to the dynamic Covid situation. The CFVP functions in Pune included: (i) a hybrid approach of deployment of traditional IEC platforms in conjunction with social media especially instant messaging through WhatsApp, (ii). planning and implementation of camp-based approaches for COVID-19 testing and vaccination as per perceived needs of the community through support from dedicated Taluka (sub-district) coordinators stationed

by the NGO (iii). Deploying access to a multilingual Knowledge Management System (KMS) platform for online training of village level stakeholders especially VTF members and having a repository of pandemic management information resources issued by both government and non-governmental public health organizations (Figure 1). The CFV-KMS portal served as a one-stop-shop for program stakeholders to easily access and download user-friendly program resources in their preferred language at any time. During the pandemic when movement of people was restricted, KMS provided instant access to program resources for self-learning, awareness generation, and capacity building. Detailed processes, roles and responsibilities of stakeholders, audio-visual learning modules, pictorial guidebooks, and BCC/IEC material on the portal helped people to better understand the project and know what was expected of them. Program resources available on the portal were also extensively used by Master Trainers to conduct daily online training of Sarpanchs, VTF members and other stakeholders.

A logic model guided by a theory of change in the CFVP envisaged an increase in adaptive, absorptive, and transformative capacity of the communities mediated by principles of civic mindedness and social responsibility towards strengthening individual agency for adopting positive Covid appropriate behaviors and instilling resilience (Figure 2). In this context, the vulnerable community on having improved accessibility to resources were expected to develop increased COVID-19 awareness which enables adherence to Covid appropriate behaviours translating into increased COVID-19 vaccination acceptability and confidence, reducing viral transmission, and promoting positive health seeking behaviours for reducing Covid related hospitalizations and deaths.

Figure 1. Interventions delivered through the Covid Free Village Program (CFVP) in Pune, 2021-22

Figure 2. Theory of Change Model of the Covid Free Village Program (CFVP) in Pune, 2021-22

Study Design

This analysis reports the quantitative results of a large observational mixed-method concurrent triangulation study conducted from May 2022 to July 2022. In this retrospective impact evaluation, quantitative data was collected from sample households from villages across intervention (CFVP) and comparison arms (CFVS) arms. The CFVS implemented the recommendations of the government for maintaining Covid free villages without any external support, while the CFVP implemented the same with support from the NGO as described above. We created a matched sample of non-exposed (to CFVP) villages and households from an adjoining district, Satara, a predominantly rural district sharing its north border with Pune. Satara has a total population 3,003,741 with 81% being rural and rural population of Pune is 3,678,226, 39% of its total population [17, 18].

Sampling

Sample size estimations were based at 5% significance level (alpha error), 90% power, expecting 85% (CFVP) success in intervention and 80% success in comparison group (CFVS), with 20% non-response rate. A minimum of 1,500 households in the intervention and control district each were required for estimating the change in outcomes. Additional 500 households were selected in the control district to account for any loss of power after matching analysis.

For household survey, a random, 2-stage stratified sampling was followed. In the first stage, all villages in Pune (n = 1173) and Satara (n=1,668) districts were separately stratified into 4 equal stratum based on average number of household per village, with the stratum 1 containing the smallest number of households per village and the stratum 4 containing the largest number of households per village. Total sample of 1,500 households in Pune district were allocated to each group, with a varied proportion (50% households per village from stratum 1; 40% from stratum 2; 30% from stratum 3 and 20% for stratum 4), which determined minimum number of villages to be covered in each stratum and in Pune. Equal number of villages, with similar socio-economic and village

infrastructure status, were selected from each stratum in Satara. Similarity in socio-economic and infrastructure status of villages in each stratum was determined through a statistical matching exercise. A total of 2,000 households were allocated to the selected villages in Satara (control) district, in the same proportion as in Pune district.

In the second stage, households from each village were selected using a Systemic Random Sampling method. A household list in each village was obtained with the help of local authority and households were systematically selected from the list using the varied proportions (50% households per village from stratum 1; 40% from stratum 2; 30% from stratum 3 and 20% for stratum 4) in villages. We also provided scope of replacement of households in case of non-response in the control villages.

Recruitment

Data collection was conducted from the month of May to June 2022 by an external survey agency that had no role in the implementation of the CFVS or CFVP. A total of 25 field investigators along with five supervisors and two qualitative researchers were involved in the process of data collection. Field investigators were provided three days residential training before commencement of the data collection where they were explained the purpose of the CFV project, household selection method, consent procedures, and administration of the tool. After two days of classroom training, one day field visit was planned for the participants to an environmental sensitive area to familiarize the trainees on how to implement the tool in real-world situations.

Quality assurance in data collection was assessed by the first and third authors through independent supervisory field visits and virtual meetings and feedback from the data enumerator teams. Data was collected using a close-ended interview schedule prepared in English that was translated into Marathi and Hindi languages and that had distinct thematic sections for capturing information associated with each VTF function (Appendix).

Interviews were conducted with an adult member of the household that was preferably the head of the household and/or having the highest educational qualification within all household members

although due to operational challenges, the adult household member available and willing to participate were also interviewed. The interview schedule collected information on socio-demographic characteristics of the household, COVID-19 vaccination status in terms of number of doses received, associated information like site of initial vaccination, distance from the vaccination site, awareness regarding severity of COVID-19 infection, awareness and adherence to Covid appropriate behaviors, utilization of the Aarogya Setu official government contact tracing and awareness application, accessibility and utilization of COVID-19 testing services, COVID-19 morbidity related to hospitalization, Covid related government scheme utilization, etc. The interview schedule was pretested in 50 households in a different intervention village to assess participant comprehension and further changes were made in few items based on the analysis of the responses and feedback from the field investigators.

Study measures and Analysis

Two stage matching analysis was performed to create the control groups (non-intervention population). First, selected 16 villages in Pune (intervention/CFVP) were matched with villages in Satara (comparison/CFVS) using a range of socio-demographic and village infrastructure indicators. These indicators were collected from the Village directory of the Census of India 2011. Second, within the selected villages of Pune and Satara, the households were matched using socio-demographic and health indicators and only the matched households were further used for the impact assessment analysis.

1. ***Matching of villages***

   Initially we had 1,745 villages for Satara district and after removing the villages with extreme population numbers (less than 100 and more than 15,000 population), 1,668 villages were used for the matching analysis. Considering a combined list of the 16 sample villages in Pune and all the villages (after removing extreme sized villages) in Satara we generated propensity score using a logit model (Annexure Table S1). The estimation the logit model and predicted

propensity score used equation 1: $P((T_i=1)/X_i)=\frac{e^{\beta x_i}}{1+e^{\beta x_i}}$ ……. (1)

Where, T_i indicates whether village i belong to Pune (intervention) district. The vector Xi indicates household demographic, socio-demographic and infrastructure indicators, and β is a vector of the parameters to be estimated.

2. Using the estimated parameters, we generated a linear prediction of propensity score for each village. Using the 'nearest neighbor matching' method, control villages were selected for each intervention village. We selected two control villages with the nearest propensity score for each intervention village, in case replacement of village was required for any logistic reasons.

3. ***Household matching:***

Even after village level matching of socio-demographic and infrastructural indicators, we expect some household level differences to prevail in villages. We further controlled such differences by using a household level matching in selected sample village using the similar exercise as mentioned in the village level matching. Matching reduced the number of sample households by about 10%, both in Pune and Satara, 119 households in Pune and 280 households in Satara. However, there was significant reduction the overall imbalance of the sample (Annexure Table S2)

4. Logit results in household matching reflect that households in Pune were more likely to have female respondents, are more likely to be Hindu, have a joint family and less likely to have elderly over the age of 60 years of age and a family member between age of 6-18 years. However, households in Pune are more likely to have at least one member with education level of primary school or above (Annexure Table S3A and S3B).

5. *Outcome indicators*

The CFVP was expected to enhance awareness in the population about COVID-19

appropriate behaviour for protection against the disease. Using 13 dichotomous indicators of awareness about the COVID-19 challenges and precautions, we conducted Principal Component Analysis (PCS) to generate an awareness index of population. A similar index was also generated for awareness about the CFVP. We also generated a combined awareness index combining the two dimensions of awareness. This change in awareness is expected to translate into higher COVID-19 vaccination coverage and reduced mortality due to the disease.

6. Secondary outcome indicators used for assessing the effect of the programme included (i) Number of deaths detected per 100,000 population (ii). COVID-19 vaccination coverage (iii). Perceived effect of COVID-19 on comorbid persons, (iv). use of preventive measures such as frequency of handwashing or sanitizing and adherence to the habit of wearing mask, iii) difficulty in accessibility and affordability of the essential hygiene products, (v) use of *Aarogya Setu* digital app as for contact tracing, for self-assessment and understanding the risk of infection status and for knowing updates, advisory & best practices related to COVID-19, (vi). use of the vaccination facilities in public and private settings, (viii). availability of the transportation for the villagers with site of vaccination over 1 Km, and (ix). regular availability of some other medical services such as regular under-3 immunization, regular antenatal care service and access to ambulance / emergency transport for pregnant women and assess to the medicines to the patients with chronic diseases.

7. *Estimating effects of CFVP*

The effect of the CFVP on different outcomes were estimated using “matched” household data (n=1,381 in Pune and n=1,780 in Satara) across the intervention and comparison arms. Linear regression (equation 2a) and limited dependent variable (equation 2b) models were used for the relevant outcomes.

$$y_{ij} = \alpha + \beta_1 P + \beta_2 X_{ij} + e_{ij} \quad \text{..... (2a)}$$

$logit(y¿¿ij) = \alpha + \beta_1 P + \beta_2 X_{ij} + \varepsilon_{ij} ¿$ ………………………………..…. (2b)

Where, 'y_{ij}' is outcome of interest for households 'i' living in village 'j', 'P' is a dummy variable for households living in Pune, 'X_{ij}' are socio-economic and health indicators of households and 'e_{ij}' and ε_{ij} are usual error term in the respective equations. 'β_1' is the main parameter representing the effect of the programme intervention on outcomes.

8. We estimated 'β_1' for the outcomes related to awareness index coefficient using equation (1) and 'Odds Ratios' of other outcome indicators using equation (2) for all other outcomes. For a robustness check of any village specific effects, we also used village dummies as control, and we didn't find any major difference in the results except a couple of outcomes at the margin of statistical significance turning out to be statistically insignificant.

9. *Subgroup analysis*

With the expectation that the effects of the CFV programme should be equitable and therefore higher amongst low socio-economic status and vulnerable populations, we conducted two subgroup analyses: in the first socially disadvantaged subgroup that comprised the Scheduled Caste (SC) and Scheduled Tribe (ST) households that were grouped and analysed collectively while in the second subgroup, the members of households with maximum education up to middle standard were grouped. The SC and ST are officially considered as representing the most socio-economically disadvantaged groups in India [19].

Ethical considerations

This study is compliant with the declaration of Helsinki. Written and informed consent was obtained from all the study participants. The study was approved by the Institutional Ethics Committee, Indian Institute of Public Health - Delhi. Participation was voluntary and the participants could omit answering any questions. All personal identifiers were removed prior to data analysis through development of an anonymized dataset to ensure privacy and confidentiality of the study

participants. No monetary incentive was provided to any of the participants for participation in this study.

Results

The CFVP in the rural areas of Pune district of Maharashtra conducted nearly 8 months since its inception had near universal uptake by the villages (N=1300). The sociodemographic characteristics of participants in Pune and Satara are reported in Annexure Table S4.

Awareness about COVID-19 challenges and COVID-19 control programmes

Table 1 reports the effect of the CFV programme on the awareness level of the population regarding "COVID-19 variants and preventive measures" and COVID-19 control programmes (CFVP or otherwise). The awareness index of COVID-19 variants and preventive measures was higher in Pune (intervention) by 0.55 (CI=0.455-0.636) points compared with that in Satara (control). Awareness was higher in Pune for almost all indicators, with awareness about "handwashing and vaccination" reflecting the highest change (Annexure Table S5). Similarly, the awareness on COVID control program (CFVP or CFVS) in Pune was higher by 0.22 points (CI=0.79-0.36) index level as compared to that in Satara. Among the different individual indicators of COVID-19 control programmes (including CFVP), awareness about government initiatives such as "focus awareness campaigns and awareness of public announcements" and "social media as methods of spreading awareness" were also higher in Pune. The combined awareness level was higher in Pune by 0.43 points (CI = 0.29-0.58). (Table 1)

Table 1. Effect of CFVP program intervention on awareness levels of participants in intervention district (Pune), 2022 – Retrospective Impact Evaluation

Variable	Index for COVID-19 awareness	Index for CFVP related awareness	Index for Combined awareness
Intervention district Coefficient (CI)	0.546 (0.455-0.636)	0.218 (0.079-0.358)	0.430 (0.285-0.575)

	P<.001	*P=.002*	*P<.001*
Control	SES	SES	SES
N	3,183	3,183	3,183
R2	0.1419	0.1075	0.1357

The CFVP had a positive impact on COVID-19 safety protocol in general. Probability of responding "yes" for "handwashing with soap/ sanitizer at least 4 times a day" and "wearing a mask while leaving the house" were approximately 23% (3%-45%) and 17% (0-38%), respectively, higher in Pune. Also, participants in Pune had significantly lower probability (in the range of 30% to 40% lower probability) of facing any difficulty accessing these prevention materials (Table 2)

Table 2: Effect on use of preventive measures and any difficulty faced in accessing preventive materials in intervention district (Pune), 2022 – Retrospective Impact Evaluation

Indicators	**OR (95% CI)**	**N, Pseudo R^2**
Wash your hands with soap/ sanitizer at least 4 times a day	1.225 (1.034-1.451) *P=.019*	N=3183, R^2= 0.047
Wear the mask while leaving the house	1.169 (0.993-1.375) *P=.060*	N=3183, R^2=0.0352
Faced any difficulty in accessing or affording Soap	0.688 (0.515-0.919) *P=.011*	N=3183, R^2=0.060
Faced any difficulty in accessing or affording Sanitizer	0.606 (0.473-0.776) *P<.001*	N=3183, R^2=0.056
Faced any difficulty in accessing or affording Mask	0.580 (0.445-0.755) *P<.001*	N=3183, R^2=0.057

Perception about effect of COVID-19 on patients with comorbidities

The probability of perception of COVID as a serious illness in patients with heart disease was 22 percent (CI-1.036-1.439) higher in Pune compared to Satara, in patients with hypertension was two and a half times higher (CI-2.076-2.914), in patients with lung disease was almost twice higher (CI-

1.606-2.298), and in people with low immunity was 57 percent higher (CI-1.339 - 1.854) (Table-3).

Table 3 Perception of the effect of COVID-19 on patients with comorbidities in intervention district (Pune), 2022 – Retrospective Impact Evaluation

Indicators	OR (95% CI)	N, Pseudo R^2
Perceived effect of COVID-19 on comorbid		
COVID-19 disease is more serious in people with Heart disease	1.221(1.036-1.439) *P=.017*	N=3183 pseudo R^2 =0.024
COVID-19 disease is more serious in people with Diabetes	1.059 (0.901-1.203) *P=0.485*	N=3183 pseudo R^2=0.021
COVID-19 disease is more serious in people with Hypertension	2.460 (2.076-2.914) *P<.001*	N=3183, pseudo $R^{2=}$0.062
COVID-19 disease is more serious in people with lung disease	1.921(1.606-2.298) *P<.001*	N=3183, pseudo R^2 =0.049
COVID-19 disease is more serious in people with low immunity	1.576 (1.339-1.854) *P<.001*	N=3183, pseudo R^2=0.060

COVID-19 testing

Probability of people getting tested for COVID-19 was higher in Pune by 32 percent (CI-1.126-1.553), though odds of availability of the testing camps in the village was 84 percent (CI-0.133-0.191) lower in Pune (Annexure Table S6).

COVID-19 Mortality

On comparing the overall district level population estimates, Pune (rural areas) had significantly lower COVID-19 deaths per 1,00,000 population compared to Satara rural during the period of observation. The number of COVID-19 deaths per 1,00,000 population in Pune rural district in

September 2021, October 2021, November 2021, December 2021, January 2022, and February 2022 was 2.5, 2.42, 1.09, 0.46, 0.68, and 0.54, respectively. In Satara, the corresponding number of COVID-19 deaths per 1,00,000 population in September 2021, October 2021, November 2021, December 2021, Jan 2022, and February 2022 was 37.11, 29.96, 1.85, 14.26, 1.81, and 0.86, respectively.

Within the sample, in Pune, five households reported a death of a member in their family and 54 households reported hospitalization of a family member due to serious COVID-19 disease, while in Satara, 12 households reported a death of a member in their family and 87 households reported hospitalization of a family member due to serious COVID-19 disease during the pandemic.

COVID-19 Vaccination coverage

On comparing COVID-19 vaccination coverage in the district level in February 2022, Pune rural had 1st dose coverage of 107.3% and 2nd dose coverage of 94.7% compared to Satara with 83.1% and 71.3% coverage, respectively.

On comparing COVID-19 vaccine coverage in the sample, in Pune, 79.3% had received two doses, 10.6% had received single dose, and 2.8% had also received precaution (booster) dose, while in Satara, 88.4% had received two doses, 7.4% had received single dose, and 1.7% had also received precaution (booster) dose.

Table 4 reports the difference in the utilization of vaccination facilities across Pune and Satara. Probabilities of population 60 years and above receiving vaccination at government, private or camp facilities were lower in Pune compared to Satara but the probabilities of receiving vaccination by below 60 years' age population in all these three types of facilities were higher in Pune. Probability of the villagers being provided with transportation services if the site of vaccination was over 1 km was almost 41 percent (CI-0.976-2.035) higher in Pune, but this difference was not statistically significant (Table 4).

Table 4: Difference in the Utilization of Vaccination Facilities in the intervention district (Pune), 2022 – Retrospective Impact Evaluation

Indicators	OR (95% CI)	N, Pseudo R^2
Use of Vaccination Facilities		
The first dose of the COVID-19 vaccine for the eligible household members of the age 60 years and above was administered at the government facility	0.28 (0.239-0.335) *P<.001*	N=3183, R^2 = 0.0831
The first dose of the COVID-19 vaccine for the eligible household members of the age 60 years & above was administered at the village vaccination camp	0.754 (0.622-0.893) *P*=.001	N=3183, R^2=0.099
The first dose of the COVID-19 vaccine for the eligible household members below of the age 60 years and above was administered at private facility	0.315 (0.161-1.609) *P=0.165*	N=2128, R^2=0.168
The first dose of the COVID-19 vaccine for the eligible household members below the age of 60 years was administered at the government facility	0.327 (0.276-0.387) *P<.001*	N=3183, R^2=0.0609
The first dose of the COVID-19 vaccine for the eligible household members below the age of 60 years was administered at private facility	4.826 (2.220-10.492) *P<.001*	N=3079, R^2=0.1026
The first dose of the COVID-19 vaccine for the eligible household members below the age of 60 years was administered at the village vaccination camp	2.491 (2.112-2.940) *P<.001*	N=3183, R^2=0.0546
The transportation was provided for the villagers if the site of vaccination was over 1km	1.409 (0.976-2.035) *P=.067*	N=3128, R^2=0.0566

Other indicators:

Although installation of the *Aarogya Setu* contact tracing app was not statistically significant across Pune and Satara, the probability of using the app for obtaining updates, advisory, and best practices related to COVID-19 was higher in Pune by 53% compared to Satara. The probability of the availability of routine medical services, continuing routine child immunization, routine antenatal services, and medicines for chronic diseases had significant higher odds in Pune compared to Satara. Furthermore, the probability of observing COVID-19 related stigma or discrimination in their locality was 68 percent lower (CI=0.133-0.191) in Pune compared to Satara (Annexure Table S5)

Sub-Group Analysis

Group with the highest household education level up to middle school

The effect of the CFV program on the awareness index of COVID-19 variants and preventive measures was higher in Pune by 0.88 (CI=0.674-1.089) points. When the highest household educational level was restricted to middle school, the awareness about COVID control program (CFVS/CFVP) was also 0.69 (CI-0.36-1.021) points higher, with the combined awareness level of both higher by 0.95 point (CI=0.612-1.306) (Annexure Table S6). The effect of CFVP on the adherence to the safety protocol such as hand washing and wearing mask was not significant in this subgroup although the probability was 60 percent lower in experiencing difficulty in accessing soap (CI- 38%-81%) or sanitizers (CI-32%-75%). Perception about COVID-19 affecting comorbid person more seriously was found higher in this subgroup. Probabilities of the perceived seriousness of COVID for patients with hypertension was almost 6 times (CI- 3.726-9.390) higher and for the patients with lung disease 2.7 times (CI- 1.709-4.283) higher. There was no significant difference seen in the use of *Aarogya Setu* app in the group except for the probability of the usage of app for knowing updates, advisory & best practices related to COVID-19 was 2.8 times (CI- 1.02-8.042) higher. For the members over the age 60 years and above, the probability of receiving vaccination in the government facility was significantly lower. The probability of the eligible members under the

age of 60 years receiving vaccination at village camp was twice higher (CI=1.627-3.476). There was a positive effect of the CFVP on accessibility to other medical services. For instance, the probability of regular under-3 immunization and regular ANC check-up was almost twice higher in the group. Also, probability of availability of emergency medical transport for pregnant mothers was 16 percent higher (CI-1.119-2.41) and availability of medicines to the patients with chronic diseases was 2.6 times (CI- 1.791-3.934) higher in this group. (Annexure Table S7)

Group with socially disadvantaged households

In the group comprising socially disadvantaged households the results were in favour of Pune for all the three awareness indices, though it was only significant for the awareness index of COVID-19 variants and preventive measures which was higher by 0.45 (CI- 0.236-0.671) points. The CFV program had positive impact on the adherence to safety protocol in this subgroup. The probability of "washing hands with soap/sanitizer at least 4 times" a day was 54 percent higher (CI-1.008-2.366) and using mask was 95 percent (CI-1.29.7-2.932) higher. Perception about COVID-19 affecting comorbid person more seriously was found higher in this group. Probability of the perceived seriousness of COVID in patients with lung disease was 86 percent (CI-0.756-1.762) higher and that in hypertensives was almost thrice (CI-1.953-4.484) in this group. There was no significant difference seen in the use of *Aarogya Setu* app. Probabilities of the eligible members receiving vaccination at government facilities were lower, but the probability of receiving COVID-19 vaccine for the eligible household members below the age of 60 years at the village vaccination camp was 10 times higher (CI- 6.2-16.195). The probability of being provided with the transportation for the villagers if the site of vaccination was over 1 km was higher by 3.6 times (CI-1.028-13.206). The CFVP also positively affected the availability of the other medical services. For instance, the probability of receiving regular ANC check-up and availability of medicines to the patients with chronic diseases was three times higher (Annexure Table S7).

Discussion

Rural populations in lower middle-income countries (LMICs) including India experienced major barriers in their pandemic preparedness due to pre-existing lacunae in public health preparedness and infrastructural deficit. The CFVP applied the principles of village empowerment, volunteerism, and efficient government – citizen partnership interlaced with effective supervision and management with a vibrant grassroots level partner to target community mobilization, behavior change, and augment government and health system efforts.

A comparison of mortality trends in the districts indicate Pune (rural areas) had significantly lesser COVID-19 deaths per 1,00,000 population compared to Satara but this trend predated the implementation of the CFVP which negates a temporal relationship. Furthermore, the number of COVID-19 deaths in both the sampled populations were very low. Overall, district vaccination coverage was higher in Pune (rural areas) compared to Satara but within our sample, Satara had overall slightly higher two-dose vaccination coverage.

However, our analysis suggests that rural households in Pune (intervention district) had substantially improved awareness regarding multiple aspects of Covid appropriate behaviour, higher adherence to the recommended practices such as handwashing with soap and water, and their persistence compared to those practices in Satara that constituted the comparison group households. This finding is also confirmed by reporting of significantly increased utilization of IEC through both traditional and social media in Pune compared to the comparison site. It is well established that effective health information campaigns have a pivotal role in improving public awareness and protective healthy behaviours [20]. Previously, studies conducted during the early phase of the COVID-19 pandemic in South Asia have also reported some evidence of audio messages, and short message service texts to be effective in improving the awareness and practices of rural communities especially amongst women [11, 20, 21].

A study from rural Bihar, a low-income Eastern state of India, reported public health messages

related to safe sanitation and hygiene had higher recall in households experiencing economic disruptions and were associated with improved Covid-appropriate behaviours related to social distancing and WASH during the early phase of the COVID-19 pandemic [22]. A Chinese study also found social media to be an effective tool in promoting Covid appropriate behaviors in the general population of their country [23]. The findings from this study are indicative of the potential of such holistic community-based interventions in the attainment of behaviour change driven public health goals during public health emergencies. Furthermore, the perceived lowering of COVID-19 related stigma in the intervention site is a significant finding since stigmatization during the pandemic was globally known to worsen mental health, intention to vaccinate, hinder treatment access, and lower quality of life in vulnerable populations resulting from discriminatory behaviours [24, 25]. The lowering of Covid-19 related stigma in the general population therefore could have indirectly influenced several potential beneficial public health outcomes unliked to Covid-19 related mortality.

Although, the improvement in COVID-19 awareness of Pune villages could be attributed to the CFVP, a causal relationship cannot be conclusively established since the baseline knowledge, attitude, and practice information of both sites was unavailable accentuating the risk of endogeneity [26]. Furthermore, a potential confounder was Pune district has higher (nearly 60%) urban demographics compared to Satara which is mostly ruralized (~80%) so potential interaction of participants from the Pune rural site with urban areas rendered them at advantage of exposure to other urban government/non-government initiated COVID-19 IEC campaigns. Nevertheless, we tried to minimize this risk by matching the two districts based on large number of sociodemographic indicators at the village and household level. Furthermore, sustainability of practices promotive of Covid appropriate behaviour is an important long-term indicator of community protectiveness and resilience against other infectious diseases also [27, 28].

Previous studies from LMICs including India have indicated that accessibility to COVID-19 vaccination services could inhibit the total vaccination coverage especially in rural and underserved

communities [29, 30]. Although, we could not estimate the overall impact of CFVP on COVID-19 vaccination coverage in Pune, we observed some factors suggestive of increased vaccination service accessibility and reduced vaccine hesitancy. For instance, in the Pune (rural areas) district sample, a significantly higher proportion of households had COVID-19 vaccination beneficiaries that were vaccinated for their first dose at the village vaccination camp that facilitating reaching the unreached vulnerable populations especially the elderly and the comorbid. Furthermore, vulnerable groups, socially and educationally, benefited from the CFVP intervention at rates that were comparable to the socioeconomically advantaged groups suggesting of its high equitability.

Our assessment of the CFVP suggests the potential applicability of a similar model in rural community empowerment processes. Platforms like the open-access multi-lingual online KMS knowledge portal, one of the core strategies of the CVP to address access, awareness, and information deficiency barriers during the pandemic, can be developed for ease of access to accurate and validated health information to avoid infodemics and scaling up behavior change communication initiatives [31]. Our findings suggest that comprehensive online program resources can also be extensively used for training of grassroots stakeholders in rural areas as demonstrated within the CFVP. The evidence from this study is also indicative of the applicability of the CFVP model in controlling local outbreaks, epidemics, disasters, and future pandemics in rural areas. The broad principles of empowerment of villages, encouragement to volunteerism, and community mobilization can be replicated in emergency like situations. Nevertheless, the extent of community engagement and mobilization may be dependent on the perceived susceptibility and magnitude of the specific outbreaks or epidemics in the affected population that was unusually high during an unprecedented epidemic.

Sensitization of community stakeholders against the threats of disease and their solutions, rapid estimation of village health needs and the early deployment of IEC, both, traditional, and virtual through community support and mobilization were the cornerstone of the CFV program. Building

greater trust in the existing public health system and improving service delivery to meet community health needs and expectations can contribute towards accelerating progress towards desired health indicators and outcomes in rural areas of LMICs.

A key feature of the CFVP is the application of professionally trained sub-district (*Taluka*) coordinators from an NGO acting as the interface between district and the village administration who also supported sensitization and community mobilization effort. In non-outbreak periods, provision of such coordinators will be a constraint due to the associated costs.

Future studies should also explore the potential applicability of the CFV model for long-term impact in strengthening social public health infrastructure especially human capital in tackling public health challenges in low-resource rural settings. The applicability of a similar model for health promotion enabling the prevention of high burden chronic lifestyle diseases especially Diabetes and Hypertension in areas with limited health services warrants further exploration.

Limitations

There were some significant limitations in assessment of the COVID-19 vaccination program between Pune and Satara. First, as information on monthly COVID-19 vaccination statistics was unavailable, the current study was unable to compare the rate of change in vaccination coverage between districts that precluded the assessment of the effectiveness of the VTFs in accelerating the pace of COVID-19 vaccination in Pune. Second, information on booster dose vaccine utilization was mostly unavailable as the campaign for the same was initiated towards the end of the study period. Third, there was no available information on vaccine wastage data that could have possibly reduced from CFV initiatives due to the accurate prior estimation of the beneficiary count in villages preceding vaccine camps.

Additionally, the choice of the comparator district was not ideal, but the choice was limited due to factors of administrative and logistic feasibility. For instance, Pune has 39% rural population compared to Satara which has 81% rural population. Differences in the extent of spread of infection

in rural Pune and Satara, which mediated the extent and quantum of work done to prevent and contain the infection may also affect the study findings. Finally, The CFVP's KMS portal was a crucial component of the program but the utilization of the portal in terms of access and downloading of resources (guidelines, videos, IEC material) stratified by the village stakeholders was not captured during the implementation of the CFV which prevented assessment of the extent and patterns of its net utilization and its overall usefulness [32].

Conclusions

This retrospective impact evaluation of a large-scale rural community based multipronged intervention for COVID-19 risk reduction and resilience in a single district in Western India could not establish a significant change in overall COVID-19 vaccination coverage or reduction in COVID-19 deaths due to the intervention. However, a significant improvement in knowledge and sustained adherence to Covid appropriate behaviors was observed in the intervention group. Community based health interventions engineered by grassroot NGOs and trained volunteers with integration of novel technology and community engagement processes may have considerable applicability in health promotion, protection, and preparedness during future outbreaks and epidemics.

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Conflicts of Interest

The authors declare having no conflicts of interest. MD, NJ, AM belong to the BJS and were not involved in the quantitative analysis and the data collection which was conducted by a third-party agency unrelated with the planning or implementation of the Covid-Free Village Programme (CFVP).

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Data availability statement

The dataset accompanying this study is available on request to the corresponding author.

Author Contributions

Declaration
No generate AI tool was used in drafting this manuscript

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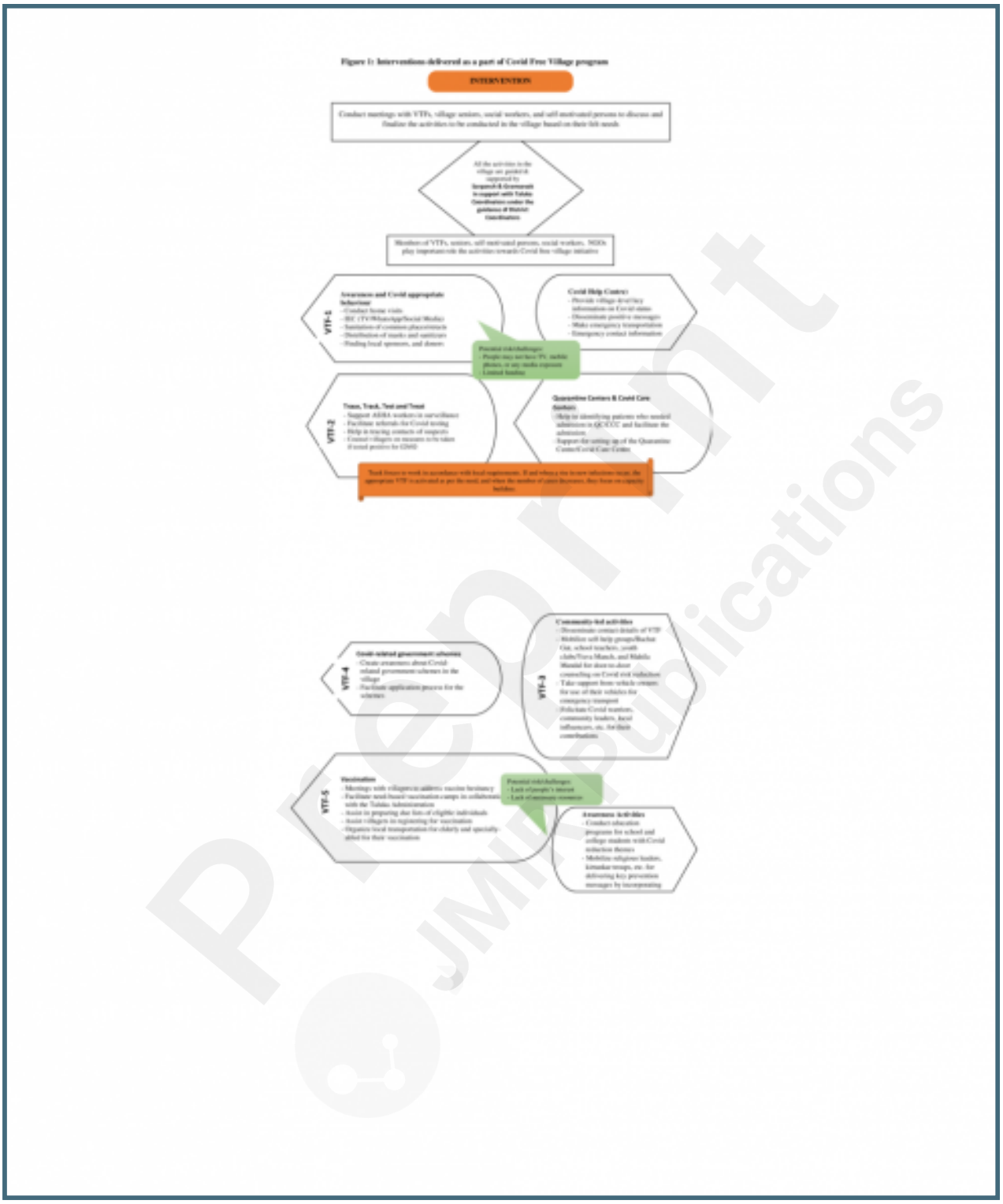
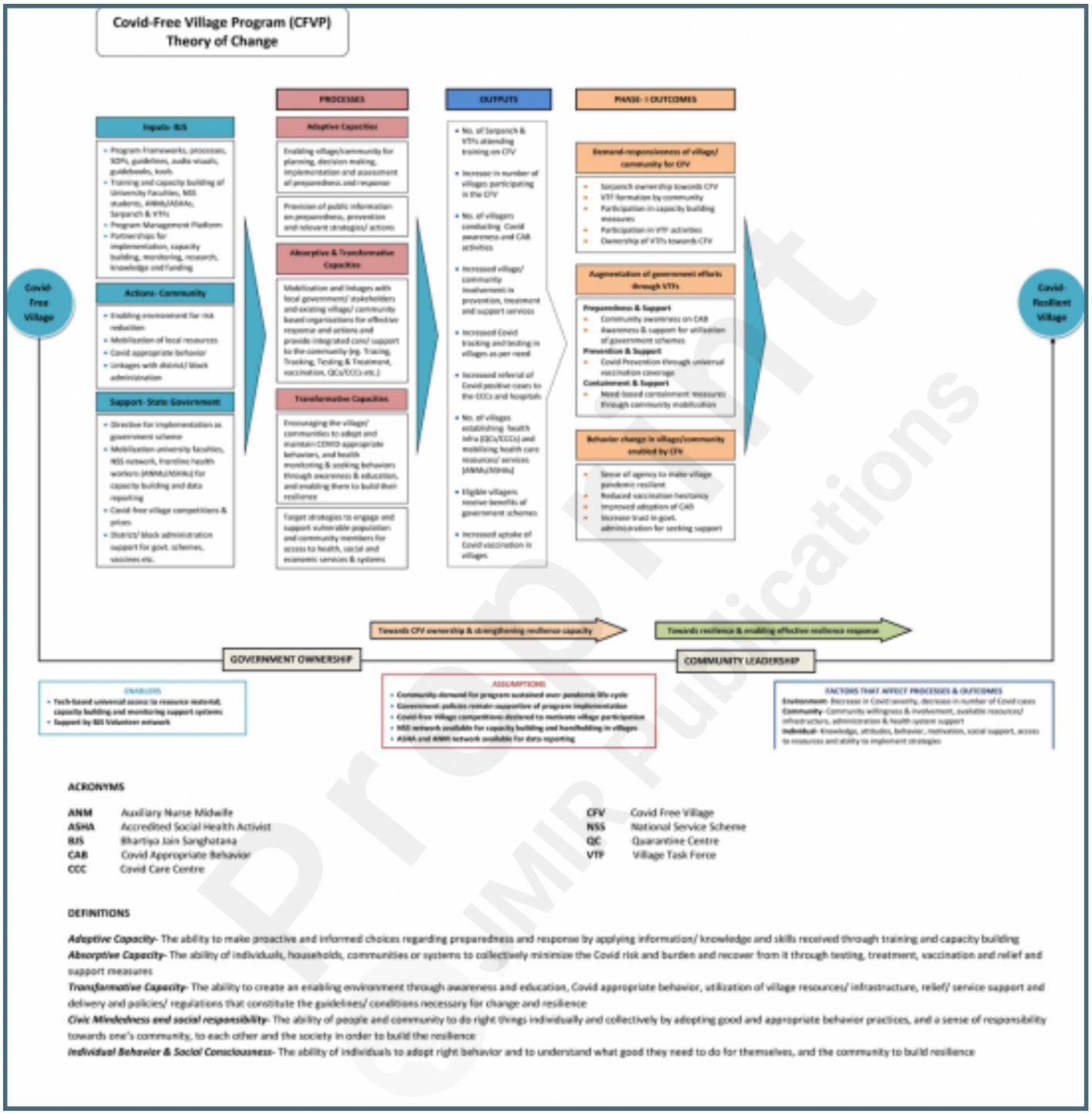
Supplementary Files

Figures

Interventions delivered through the Covid Free Village Program (CFVP) in Pune, 2021-22.



Theory of Change Model of the Covid Free Village Program (CFVP) in Pune, 2021-22.



ACRONYMS

ANM	Auxiliary Nurse Midwife
ASHA	Accredited Social Health Activist
BJS	Bharatiya Jain Sanghatana
CAB	Covid Appropriate Behavior
CCC	Covid Care Centre
CFV	Covid Free Village
NSS	National Service Scheme
QC	Quarantine Centre
VTF	Village Task Force

DEFINITIONS

Adaptive Capacity- The ability to make proactive and informed choices regarding preparedness and response by applying information/ knowledge and skills received through training and capacity building

Absorptive Capacity- The ability of individuals, households, communities or systems to collectively minimize the Covid risk and burden and recover from it through testing, treatment, vaccination and relief and support measures

Transformative Capacity- The ability to create an enabling environment through awareness and education, Covid appropriate behavior, utilization of village resources/ infrastructure, relief/ service support and delivery and policies/ regulations that constitute the guidelines/ conditions necessary for change and resilience

Civic Mindedness and social responsibility- The ability of people and community to do right things individually and collectively by adopting good and appropriate behavior practices, and a sense of responsibility towards one's community, to each other and the society in order to build the resilience

Individual Behavior & Social Consciousness- The ability of individuals to adopt right behavior and to understand what good they need to do for themselves, and the community to build resilience

Multimedia Appendixes

Participant interview Schedule.
URL: http://asset.jmir.pub/assets/f35e9c07dbc79d442027242113add286.pdf