

IoT Enabled Model for Improving Responses of Water, Sanitation, and Hygiene Programs to Urgent Community Needs During COVID-19

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Abstract

Communities worldwide have suffered from the COVID-19 pandemic in terms of services provided that meet their daily needs and encounter challenges associated with problems in food and hygiene supply chains. Many initiatives have responded to vulnerable communities' essential needs during the pandemic for instance delivering basic hygiene and food packages. These initiatives came as a response to rapid need assessment to prevent the transmission of COVID-19 and provide basic needs for children and women and people with special needs. However, there have been several problems and drawbacks in service-providing mechanisms resulting in significant delays in delivery time, errors in targeting, uncertainty in the selection, and factors impacting the response programs in general. This study aims to identify the right categories of people and their urgent needs as well as the efficient distribution mechanisms during lockdowns to accelerate the response plans and meet the urgent needs of targeted groups during emergencies. We have developed a Community Needs Response Model integrated with IoT concepts to reduce errors, delays, and incomplete response plans and strategies. The model has shown its ability to help governments, NGOs, and other involved agencies in needs assessment and response programs by remotely identifying urgent needs, beneficiaries, and people info including geo-location, delivery time, and improving complaints and feedback mechanisms. The results showed an improvement in the selection mechanisms through a multi-layer filter, which enables response plans to prioritize responses based on vulnerability or needs. However, further improvements are needed to integrate the model with national emergency response platforms.

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1. Introduction

COVID-19 has impacted all services and business sectors within countries in the world starting from small to large businesses (Bartik et al. 2020, Shrestha et al. 2020). Further impacts of COVID-19 included the management of social and daily services presented by local utilities for the communities like water supply and social financial support for vulnerable people (Balamurugan et al. 2021, Renukappa, Kamunda and Suresh 2021, Abu-Bakar, Williams and Hallett 2021, Al Gharaibeh 2020, Ashcroft et al. 2021, Sharif 2021, Sura Al-Harabsheh et al. 2020). This has been caused by lockdowns adopted by governments to prevent virus outbreaks that impacted personal practices in terms of hygienic practices, water consumption, and social interactions (Donde et al. 2021, Lalander et al. 2013, Dwipayanti, Lubis and Harjana 2021, Long et al. 2022, Calbi et al. 2021, Kim and Florack 2021, Campos et al. 2021, Abu-Bakar et al. 2021, Alshboul, Al-Zboon and Alzoubi 2022). During the lockdowns, people were having fear disruptions in their essential needs supply chain like food and protective materials (Aday and Aday 2020, Boudesseul et al. 2021). Despite COVID-19 was not the first pandemic and the realization of the importance of protective materials in limiting virus spread, lessons learned

seem to have been limited (Sawada et al. 2017). However, demands on personal protective equipment and hygienic materials exceeded the supply rate of these materials during lockdowns resulting in inflation in prices. This led to a shortage of materials available in the market and difficulties in obtaining them (Best and Williams 2021). This shortage in personal protective and hygienic materials was also observed during the SARS outbreak, 2003 revealing the importance of providing essential needs during emergencies (Eyre, Hick and Thorne 2016). Protective materials and any other essential needs might not be accessible and available for vulnerable people during emergencies. This will increase risk factors for children, young people, women, and the elderly in low-income communities (Patel et al. 2020).

Since the first confirmed case of COVID-19 in Jordan, on 2nd March 2020, there are 1.7 M cases up to date with a death rate of 0.08% based on global statistics provided by WHO in April 2022 (Alshboul et al. 2022). Therefore, Jordan has responded to the COVID-19 outbreak and implemented various control measures to mitigate the pandemic's impact on public health (Al-Tammemi 2020). The responses were operated and managed by a central and multi-disciplinary governmental team launched by the National Center for

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Security and Crises Management. All procedures followed the best evidence-based recommendations for implementation and were continuously updated and announced to the public through many communication channels including national e-platforms and social media. Strict measures were implemented banning all social gatherings of more than 10 persons, traveling among cities, social distancing, hygienic practices, and prevention measures, and also included strict rules during lockdowns such as closing all commercial centers on the 20th March 2020 and continued for 3 months (Al-Tammemi 2020). Governmental procedures and restrictions on communities' activities and movements were effective as there were reductions in individual mobility, retail and recreation centers, and numbers of employment at their workplaces in comparison to the baseline (April 2020) and to the recent updates as most of the restrictions are relaxed (Suleiman et al. 2020, Health, Health). Strengthening the cooperative linkage between government and society is essential to improve crisis management during emergencies and minimize the impacts of strict procedures to mitigate the pandemic impact. Such linkages will improve awareness and communication processes and direct technical and financial support to the right groups. This support includes community needs to combat COVID-19 spread such as protective materials or essential needs for individuals during curfews and lockdowns.

Governments and NGOs worldwide provided communities with essential food and hygiene kits for people in need as a response to economic and pandemic emergencies. Many countries have offered protective materials and hygiene kits to the public during pandemics as a part of social support and to encourage communities to practice infection-prevention behaviors (Song and Yoo 2020). Some of the recommendations specified contents in kits that should be sufficient to meet households' needs for one month of use and include mouth care tools (D'Mello-Guyett et al. 2020). However, the selection of hygiene items may vary according to the provider and typically consists of personal hygiene care tools. This variation in hygiene kit distribution is based on the nature that the distribution process is a complex intervention that interacts with several components as its impact varies among different beneficiaries, delivery mechanisms, and timelines (Freeman et al. 2014, Hutton and Chase 2016). Evaluating processes associated with kit distribution is similar to most public health interventions helping to observe the impacts and design intended outcomes (Moore et al. 2015). Such evaluations are essential for any other future contexts and conditions as well as modifying process implementation (Murdoch 2016, Bonell et al. 2006). To date, there have been no studies improving distribution mechanisms and selecting the contents of hygiene kits during lockdowns as has occurred during the COVID-19 pandemic.

In Jordan, there have been several responses to the community's need for protective materials for vulnerable people to control the COVID-19 outbreak and curfew conditions. These responses were implemented to deliver protective and hygienic materials to vulnerable people and came as a response to rapid need assessment reports. Kits

were distributed to people according to pre-selection criteria and the distribution process was performed door-to-door. During project implementation conducted by NGOs and international agencies, there have been many challenges in delivering services and selecting beneficiaries. The pre-selected criteria may have ignored families in need due to a lack of information, inadequate budget, miscommunication, and uncertainties associated with available data. Further challenges were associated with distribution mechanisms and tracking systems as well as drawbacks in complaints and feedback channels. During the investigation of the processes associated with delivering protective and hygienic materials, there have been many suggestions for improving and establishing e-services and automated mechanisms that organize all processes and project details. The improvements should include developing a comprehensive and effective selection process to meet all community needs and priorities.

We developed a mechanism through which the quantity and types of items in hygiene kits can be selected based on community needs and the policy of providers. This mechanism provides stakeholders with communication channels during emergencies and lockdowns to analyze complaints and feedback data to increase response time. This mechanism sought to improve the delivery process by suggesting an e-tracking system and delivery best practices to speed, accurate, and direct processes, and financial and asset management. The study came up with recommendations to optimize future and similar public health interventions. This study evaluated the effectiveness of hygiene kit distribution during COVID-19 lockdowns in Jordan and discussed drawbacks and opportunities for improvements. Gap analysis has been performed to assess the selection process for the beneficiary and if the process of distributing the kits achieved its intended outcomes. The evaluation process included the feasibility and possibility of using e-services in future similar contexts with suggestions of major pillars of the e-service platform.

Quality assurance and quality control have been implemented during all stages of the study. This will outline procedures for handling the main activities of the study such as i) how samples were selected for QA/QC check, ii) availability of records, performed analysis, mitigation and corrective actions taken, and subsequent modifications done to the processes, ii) service interruptions how communicated with the public.

2. Research Significance

Responses to the community's needs during emergencies are subject to delay and incomplete processes and inefficient selection and delivery mechanisms. Most of the needs assessment mechanisms are performed manually through voluntary processes, which are mostly more expensive and time-consuming. This study is improving a Community Needs Response Model integrated with its concepts to reduce costs associated with identifying beneficiaries and essentials. This model will accelerate the delivery rate and improve communications between all stockholders e.g. Local NGOs, representatives, delivery service providers, and monitoring agencies.

3. Methodology and Approaches

In this study, processes associated with projects aimed at delivering hygiene kits to vulnerable people have been investigated as these projects aimed at preventing transmission of COVID-19 and reflect on the performance of COVID-19-related responses under the water sanitation and hygiene program in general. One of the implemented projects in many municipalities in Jordan has been selected, and the project came as a response to a rapid need assessment report carried out in May 2020 and was implemented in 2020. The study addressed the most essential considerations that can be used as a model in any future e-services during emergencies. However, the project has been designed to distribute more than three thousand hygiene kits to about two thousand households alongside information cards for awareness purposes. Sixteen items were packed in each distributed kit and were selected based on the community's needs for protection purposes and sanitization. Previous experiences implemented by service utilities have been reviewed to develop a recommended action in parallel with focused group discussions (FGDs) performed in the municipalities. We have prepared learning questions for addressing the outcomes achieved and adoption as well as the whole distribution process during project implementation. Key Informative Interviews (KII) with representative persons were also performed to ensure that the implemented project achieved the intended outcomes and that the main assumptions made during the design phase remained valid during the actual response. The selection criteria for beneficiaries and registration processes have been discussed during FGDs and KII until we have identified targeted groups, feedback, and complaint mechanisms. Quality, adequacy, and preferences have been discussed and linked with awareness of the targeted community. The study dealt with various discussions such as improving the registration techniques for receiving services, the possibility of adopting reusable or recyclable items, and the possibility of creating self-employment opportunities.

The study included two FGDs and each of FGD event had two split groups, the first two groups consisted of 19 persons split into a 10-women group and a 9-men group. The second two groups consisted of 17 persons distributed among 10 women group and 8 men group. The groups were a mix of Jordanian and Syrian participants as the selected areas hosted refugees from Syria and each FGD was designed for 1 hour. The 4 FGDs are designed to ensure that the project reaches the right group of people, selection criterion validity, efficient coverage, and suitable timeliness of the response. Key informant interviews have been performed with 2 persons from 2 Community-Based Organizations to verify whether the project achieved the intended outcomes and whether the main assumptions made during the project designation remained valid during the actual responses. The interviews have been performed with the host community project managers in both areas. The interviews were essential to formulate key lessons and whether the project has minimized the negative effects of COVID-19. The study checked for any change in the original plan and corresponding causes and evaluated the feedback and complaints handling mechanism.

The study assesses any improvement made by the project. It has addressed the beneficiaries' feedback and compliments. Furthermore, we checked the efficiency and reliability criteria in selecting beneficiaries and the role of IoT usage in response plans during emergencies. Alternatives that can be used instead of a direct hygiene kit distribution have been evaluated by directing questions to all beneficiaries and involved stakeholders.

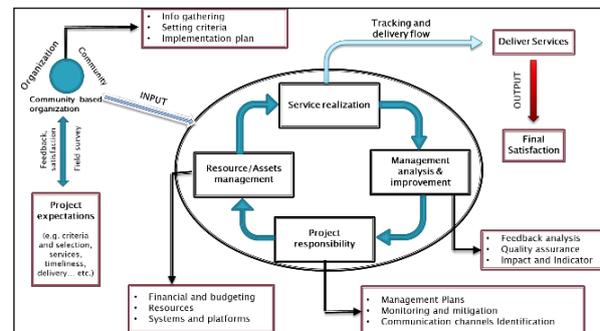


Figure 1. Different stages of the system are used to assess the processes for continuous service improvement and learning securing. The obtained expectations and needs from the benefited people during all feedback mechanisms and data collection methods, are entered as inputs to a direct Community-based organizations-community-organization channel to create a database, sitting criteria, and implementation plan. The information is entered through a coordinator to the project lead and cycled to the resource management and logistics, service realization, and goes to analysis for further action by the project lead. The process cycle ends with satisfaction and outcomes achievement.

4. Results and Discussion

4.1 Outcome achievement and adoption

The project of delivering essential needs during COVID-19 to vulnerable people including hygiene kits has been designed to access vulnerable people directly to provide them with hygiene kits during COVID-19 based on pre-selection criteria. The project has mostly achieved its designed outcomes as the estimated percentage of vulnerable people who received items formed from 70% to 85%. The FGDs indicated that the covered group of people by the services have matched the intended outcomes. Investigating the impact of distributed hygiene items on the rate of spreading the pandemic was a suggestion to improve the outcomes of water, sanitation, and hygiene programs by establishing pre-defined indicators for tracking the spreading rate of COVID-19.

The majority of people involved in the KIIs expected to benefit from the implemented water, sanitation, and hygiene Projects, although there was no pre-knowledge about the details of implementation. There has been a recommended action to improve processes of delivering assistance or delivering needs to communities during emergencies to establish a mechanism able to announce processes to all beneficiaries to inform them about the desired outcomes of the projects. In addition, the project could have been designed to provide psychological support; for instance, the vulnerable should not have felt that he/she was not left alone during the pandemic and there was external support to them to cope with emergencies. Continuous support during this critical time should have been provided to enhance the confidence level of water, sanitation and hygiene programs

to support the vulnerable. There have been many changes in the assumptions made during project implementations. These changes have affected the cost associated with packing, distribution, ordering items, and problems with the supply chain. For instance, projects have assumed that the distribution process will be implemented by external suppliers with packaging items but this assumption has been changed. The unexpected cost associated with the distribution process requested by the external service provider has changed the assumption made before the distribution. Delays during ordering kits and time loss have been noticed because of the coordination process with external service suppliers. Changes in processes and timelines revealed the importance of establishing a communication platform where data are regularly updated and processes can be tracked online and in real-time.

4.2 Benefitted people and timelines

Response believed that about 80% of vulnerable people received the services during the emergency and indicated that the percentage may increase to cover the whole vulnerable. These can be performed by providing the services of the same budget by providing only essential items and lowering the number/count of items in kits to cover a large group of people. Some of the families were excluded because of low budget, inaccurate address, high-income value or not selected by accident. The selection process excluded registered people from the selection due to a) residency situation as families are living in the same place, b) not being reached during the contact time c) because of social ethics as they can afford items or they see that many people are much more in need. Further causes are identified by about 40% of responses that there were families not selected even if they were in need because of the low family members, unemployed people, orphans, and divorced women. The criteria of services are unknown for the serviced people and the responses indicated that these criteria and response stages and timelines may be improved and announced in dynamic mechanisms by using e-services.

The majority of beneficiaries have not encountered any challenges during the services, but still the minority had a few challenges associated with the distribution process for instance no exact delivery time, inaccurate locations of targeted people, and service speed. Around 60% of surveyed entities have not observed an excluded group from the registration/distribution, while 41% of the group think the information provided and the selection criteria are unknown. The selection criteria should have been discussed with the beneficiaries and announced during the registration process. In a few cases, some people have received a call that they will receive a kit but they never did. Such cases need to be verified based on the database of the originating project. During the FGDs events, there was a major recommendation to use the most public places to announce the project, as well as use social media. We believe that a digital platform, with an appropriate user interface could have solved many of the challenges faced during the project implementation.

There were suggestions to minimize the implementation time of the door-to-door mechanisms through subgrouping

beneficiaries or center-based distribution mechanisms. These suggestions were not compatible with the lockdown rules associated with COVID-19. Many families had to carry their kits for long distances which was costly and not practical action for the most. All responses were satisfied with the implementing time and Some of these suggested that the responses were shortly before the lockdown period of the pandemic. This suggestion referred to their urgent needs for the items during the lockdown due to the limited availability and cost considerations. Most of the responses revealed the important items provided in boosting the virus spread and these responses were satisfied with assistance time and they believed that items came at the right time. 84% of the benefited people assure that the distribution was done within the designed period for the distribution and the rest have noticed the delay in the delivery time. The importance of using automated and e-mechanisms in delivery services is in urgent need. Such e-mechanisms may identify benefited people before any distribution process with a clear geographic-based delivery plan.

4.3 Targeting and multi-layer selection filter

All responses revealed that there was no idea about the selection criteria used for identifying and prioritizing beneficiaries. Furthermore, the community has not been involved in setting the selection criteria and most respondents show the importance of selecting services based on the community's feedback to maximize the benefits. The interviewed people thought that the distribution has been performed based on the number of family members or income rate. These criteria have shown many drawbacks due to the complexities associated with social and economic situations. For instance, some families have higher income rates but it is eroded due to rents, health care, loans...etc. There was a consensus that field visits or communications with beneficiaries before any further distribution is essential to investigate if families meet eligibility as many beneficiaries theoretically met the selection criteria but were not vulnerable as they have other income sources. Community-based organizations have been advised to improve the selection process and they are required to participate in determining beneficiaries and setting selection criteria. This has also been shown during assessment reports where participating with the community for setting the selection criteria seems to be essential as the people can know the category group that they belong to. The respondents and focused groups have denoted that the single layer selection filter was not efficient as many partially vulnerable were discarded from the response plans although their needs for specific needs have been approved. The single-layer selection filter applies criteria to all individuals and families and discarded groups if they do not meet the criteria or for financial causes. However, the respondents have recommended adopting weigh-criteria mechanisms where groups are classified based on their need magnitude for each type of provided item. This mechanism will maximize the benefited groups and accelerate the distribution processes

Disabled people and people suffering from chronic diseases (Heart diseases, Diabetes, high Blood pressure, Spine diseases... etc.), loans, number of family members

who are still in school or university have to be covered in the selection criteria as well as people live in rented houses or tents may include for further consideration as a minor indicator. Family net income may have been considered instead of total income as many families have high-income rates but with high rates of expenses. The FGDs emphasize the importance of discussing the social status of the selected vulnerable with Community-based organizations or representative people from the society before the distribution and setting of selection criteria. Each category of the selection criteria has a specific weight based on the type of the project and intended outcome. The weight should be in cooperation with the community and associated community-based organizations with more focus on the vulnerability to the pandemic rather than vulnerability itself in this project for example. The filter used in selecting beneficiaries can be either a selection filter “single-layer” (benefited, non-benefited) or a classification filter “multi-layer” (classify people based on their needs and importance). The multi-layer filter is a selection mechanism that can classify input data (candidates, community, targeted groups, or beneficiaries) into different categories based on their needs and/or priorities. Each category has its criteria that all people who meet these criteria will be sorted and the rest will pass to further layer for filtration. The selection criteria in each layer are either designed based on expectations, satisfaction, or project outcomes or based on criteria weight (e.g. the first layer for people who owned their houses, the second for rented houses, and the third for tents. Note that each layer may have multiple different criteria or the same criteria with different weights). The rejected people at the end process are people who are out of the project scope. The filtration using a multi-layer selection mechanism will guarantee that the budget reaches the maximum group of people and beneficiaries will have treated equity. Single-layer filtration is a selection mechanism that sorts input data based on their weight of importance and the number of beneficiaries is selected based on the available budget. The rest will have been excluded from the service as the input data were treated equally (Fig.2).

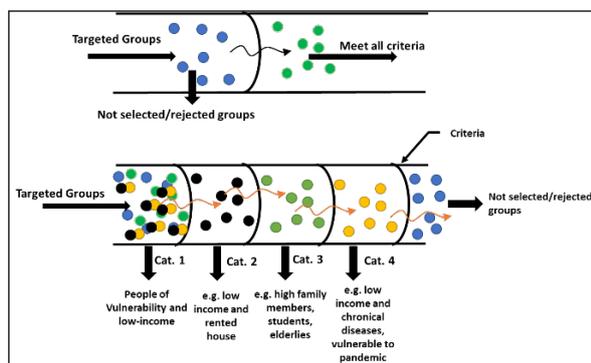


Figure 2. Comparison between two different selection mechanisms i) selection/single-layer filter (up) and ii) multi-layer filter (down). The single-layer filter applies all criteria to all candidates on an equality basis and rejects samples according to priority/weight and the rejected candidates. The selection mechanism and criteria-based filtration on up classifies targeted groups based on their needs and importance. The multi-layer selection filter has multi-filtration steps that can categorize beneficiaries based on their significant needs and the rest is passed to the next for further classification of less priority. This filter will not exclude eligible people due to the budget limitation rather than distribute resources on an equity basis and the rejected people are those who are out of the project scope.

The distribution mechanism was in person at their residencies during the response implementation at the study area, and all respondents were satisfied with this mechanism. This mechanism needs further improvements like mapping beneficiaries' locations to accelerate the process and gather detailed information about the most urgent needs based on the weights. Many complaints have been recorded during the distribution such as delivery time, duplications, and delivery loss due to the availability. However, a communication channel between the community and the delivery team has not existed and most of the respondents have indicated the importance of employing IoT concepts in creating communication channels and delivery tracking during emergencies.

4.4 Targeted groups and vulnerability

Most of the beneficiaries were satisfied with services provided during the pandemic and items are well-instructed for usage purposes. There were suggestions for improving electronic services specifically the number of provided items, user's manual, rejection, replacement, and feedback portal. The study revealed the importance of creating portals for user's profiles to update users with upcoming activities and services. The services extend to allow users to determine the number of items in each provided kit based on use rates. Furthermore, focused groups have emerged on the importance of using sustainable materials for extending lifetime instead of single-use items, for instance, washable masks. There has been a significant role in capacity building of manufacturing the provided items during emergencies in self-employment and its sustainability contribution. There has been significant approval by the respondents regarding the significant role of these capacity building particularly the use of recyclable sanitizers and face masks

Samples selected by previous reports indicated the existence of a large portion of the benefited people about information provided with the provided items or during e-channels. Distributed instructions and information have not existed in a minor ratio of about 30% and this information has consisted of detailed and helpful instructions in an understandable, visible, and feasible manner. However, the majority revealed that items in the kits were enough to help people disinfect a) tools and furniture, b) home facilities, c) adding young and children, and d) permanent sterilization. There was a consensus that the community did not receive any awareness or clarification on how the provided items in the kits can help to confront and prevent the spreading of COVID-19. There have been recommended actions provided by targeted groups including increasing the awareness level about the pandemic and the awareness campaign may be more direct with detailed explanations to boost the efficiency of responses during emergencies. IoT can be used as a tool for performing these processes with feedback service for identifying the response quality.

Responses indicated that the feedback mechanisms may be identified in an obvious manner and the provided contact numbers were not sufficient. All of the FGDs emphasize that hotlines, social media, and community-based organizations are excellent alternatives or e-services for feedback and

complaints. Results indicated that are familiar with using social media and mobile services and don't have a problem dealing with future services through any other e-portals. online systems. Further studies are needed to explore the portion of people who need training in using e-portals and other technologies in delivering services during emergencies.

Studying the level of skills in smart technologies and associated apps is essential for improving strategies in providing emergency response plans and improving services. Such studies will improve mechanisms in involving different stakeholders in processes and services provided to the communities during emergencies such as communications, delivery, and access to vulnerable people. Responses revealed that people have not experienced the existing communication channels during the pandemic and have not performed or needed feedback on their satisfaction. The information regarding any response plans during emergencies needs to be identified and informed to the communities as the responses were not aware of the existence of responses without pre-identified mechanisms. The distribution process has been announced for people who are involved or registered by community-based organizations or social utilities or through field inspection during the distribution.

5. Conclusion

There has been an urgent need to improve the response plans to the communities' needs during emergencies. The improving processes should include the delivery and selection process as well as communication channels between providers and targeted groups. Field inspection should be part of the selection process and chronic diseases may have a high weight in the selection. Update/customize the selection criteria based on the type of project and objectives, and the weight of each criterion should be justified based on the project outcomes and expectations (Perhaps according to the area, and degree of spread of COVID-19) as well as feedback from Community-based organizations. Contemplate the sustainability of the kit. Using sustainable items, such as washable items, make hand sanitizers in their home to lower the budget and establish self-support. Examining efficiency & and effectiveness through contemplating the value for money; would increase the amount of money per kit and highly increase the benefit. Establishing an online system for implementing similar services in the future. The system should be able to link the organization, community-based organizations, and community to interchange information and enhance the community and Community-based organizations' engagement in setting criteria, needs, and distribution. The system has to provide an online registration system, awareness channel, key information, feedback/complaints option, delivery track service, and geographical database.

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