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A Description of Strengthening COVID-19 Cognitive Cloud to Health Systems by Costa Rican Community Design

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Abstract

Strengthening health systems and information dissemination, and Internet connectivity in under-resourced communities, have presented profound challenges throughout the COVID-19 pandemic. This article describes research on an emerging cognitive cloud to edge community solution, the Internet Backpack, which was utilized for COVID-19 disaster response in rural and remote Costa Rican communities. The Internet Backpack utilizes novel tools and systems for controlling narrow band data pathways through selective engagement with one or more narrow band platforms of an omni-grid system. These methods enable cognitive cloud services to function reliably beyond the edge due to enhanced data compression for stronger, faster and stable transmission to off-grid environments with less latency, jitter and packet loss. In this article, we describe implementation of the Internet Backpack in Las Delicias, Los Angeles and El Palmar, three remote communities in Costa Rica. We highlight how the project has contributed to the objectives of providing Internet connectivity and consequently, increased access to COVID-19 health information in these underserved communities.

Keywords—Costa Rica, COVID-19, Health Systems, Disaster Response, Internet Backpack, Cognitive, Cloud, Edge

1 Introduction

The spread of infectious diseases is a significant public health concern and growing threat to populations and communities globally. Emerging new diseases and the return of old diseases have impacted the health status of local and global populations.[1,2] This impact is most devastating in resource poor communities with fragile health systems infrastructure. Response capabilities to reduce the spread of infectious diseases highly correlate with the level of socio-economic development and technological capabilities within countries. The lack of medical and technological resources further increases the

impact of infectious (and non-infectious) diseases on vulnerable populations in resource-constrained communities.

Thus, a central question for governments, healthcare practitioners and researchers is, how can health systems continuously build on knowledge acquired from past epidemics and pandemics and avoid the pitfalls of these crises? This article describes how new cognitive system technologies, such as the Internet Backpack, can facilitate disaster response in communities with scarcity of healthcare resources, which includes lack of skilled healthcare practitioners and lack of access to health information. It discusses a project conducted in three rural and remote communities in Costa Rica, with support of the Internet Society Foundation (2021).[3] This project was intended to meet community needs, evaluate community designs, and augment health systems' capacities to respond to disasters more effectively, during the COVID-19 pandemic. The project built on prior work on cognitive cloud to edge systems, including for education and IoT uses.[4,5,6]

At a global level, the COVID-19 pandemic made evident the need to strengthen health systems' situational awareness.[7] Many hospitals and other healthcare facilities lack the requisite infrastructure needed to appropriately respond to COVID-19 and other emerging health challenges.[8] Critical health resources, including essential drugs supplies and medical devices have been in short supply, and procurement and distribution systems have been inadequate. At the onset of the pandemic, there was also an inability to identify, treat, isolate and contain COVID-19 cases due to lack of mechanisms for coordinating health infrastructure and information.[9] Governments initially failed to implement recognized precautionary measures and to effectively communicate with their populations against transmission of the virus. The COVID-19 pandemic and its now endemic effects continue to contribute to socio-economic disruption, impede economic development, disrupt preventive health measures, reinforce the vulnerability of the most marginalized, divert national and global resources and pose unknown threats to human health security. Furthermore, the lack of Internet access has proven more deadly during the pandemic.[10] The need for improved situation awareness for not only clinical decision making but also for basic health information dissemination with millions of people worldwide with limited or no Internet connectivity is apparent, and requires further research.[7] Deployment of the Internet Backpack as a mini-ISP or cognitive community network, in community-based and rural health centers could in future potentially alleviate the shortage of healthcare workers in some of these areas and could provide governments with a mechanism to train additional healthcare professionals and to share critical health information with their populations.

2 Costa Rica Within The Global Pandemic Storm

Costa Rica's Universal Health Coverage Index is 78%, which indicates that 78% of the population has access to the full range of health services, which include health promotion, prevention and treatment.[8] Despite access to national healthcare, Costa Rica reported 568,860 confirmed COVID-19 cases and 7,343 deaths in 2021.[11] The nation's population of slightly more than 5.2 million people is about 80% urban and 20% rural.[12] San José, its capital, continued to experience the highest COVID-19 cases when compared to rural provinces.[13]

The Internet Backpack is a reconfigurable, deployable mesh network that provides cloud-managed mobile edge connectivity solutions to create resource-sharing Wi-Fi hotspots capable of providing up to 25 users and 250 devices (per backpack) a quality Internet experience.[6] The backpack connects to

the Internet either through a satellite connection for use in more remote communities, or through a cellular connection, for use in communities that have some access to connectivity infrastructure.[15]

The theory tested in rural Costa Rica is that the Internet Backpack's mini-microgrid of solar panel, battery and energy use-limited rechargeable devices permits Internet Backpack operators to sustainably serve community needs. This article discusses effective technical performance and adaptiveness to community needs when the Internet Backpack was deployed in three sites in Costa Rica.

3 Community Health Strengthening in Costa Rica Project

In 2021, in Costa Rica, 83% of the population used the Internet.[16] Internet usage is concentrated in urban areas, and there is a digital divide between urban areas and the central valley, and coastal and rural areas, where underserved and poor communities have been left behind in the challenge to connect citizens. Lack of Internet connectivity affects communities in critical ways, as the Internet is one of the most important tools for accessing education, employment, healthcare and other social services. Delay in access to these basic services has in part contributed to underdevelopment and poverty in these communities, and there appears to be no rapid solution from local and federal government to resolve these digital gaps.[15,17]

Within this context, the Democracy Lab Foundation (Demo Lab) collaborated with Syracuse University researchers and the Internet Society Foundation to deploy the Internet Backpack in communities to provide access to health information available on the Internet, as a short-term and efficient solution to mitigate the health impacts of the digital gap in Costa Rica during the COVID-19 pandemic. The Internet Backpack technology was used as a community network, and mini-microgrid, in public meeting spaces and schools, to provide Internet connectivity for community residents to access timely and relevant information relating to COVID-19. A limitation of the project is that the backpack technology was not used in healthcare settings to assist with vaccination of the population. It was also not used to augment medical technologies typically available in hospitals with high-tech capacities.

The overall project objective was to support Costa Rica's health system and consequently, its population's health outcomes, including decreasing morbidity and mortality, and combatting COVID-19 and other infectious diseases, by disseminating public health information via Internet connectivity and usage. The project sought to provide Internet connectivity for rural and remote communities, so as to provide community residents with a means to access public health information and messaging. To fulfill this objective, the Internet Backpack was deployed as a digital solution, which remains in use within the local communities.

Demo Lab is a non-profit organization dedicated to helping citizens achieve civic engagement with their governments in Central America.[5] Demo Lab has established partnerships with multiple stakeholder parties, including technical partners, local communities, government, business, and academic and civil society, and continues to work with these partners to provide Internet to these communities. Initially, the Demo Lab team mapped out the areas in Costa Rica where Internet connectivity lagged the most, using the Social Progress Index, which was constructed by INCAE Business School, Costa Rica. After these areas were mapped out, the team collaborated with community members to identify communities that would be most positively transformed by access to the Internet.[15,17]

3.1 Project Description

The Demo Lab team has delivered one Internet Backpack each to the Los Angeles and Las Delicias communities in the North Pacific region, and to the El Palmar community in the Central Pacific region of Costa Rica. Based on data collected by the community Internet Backpack operators, between these three communities, more than 1,000 persons have been connected to the Internet, including more than 500 children, who have been provided with a tool to improve their learning outcomes and future educational attainment. The project does not capture the Internet traffic of specific users. No personally identifiable data was used in this project, to protect the privacy and safety of the backpack users. In compliance with the Syracuse University Institutional Review Board, the project maintained established standards of privacy and safety.

The Internet Backpacks were delivered and deployed in these communities within one year, partially accomplishing a primary project objective of deploying the backpacks in six underserved communities. These efforts are challenging as extreme weather events, including flooding and mud slides, make it extremely difficult to access these communities.

Community leaders were selected and trained to operate the backpacks. These backpack operators engage in training community members to use the backpack to access the Internet and obtain vital health information. Many community residents continue to use the backpacks after the conclusion of the project in 2022. Expanding the project scope, the Las Delicias community board has set up schedules on when to deploy the Internet Backpack near an elementary school and the middle/high school, for students to have routine access to the Internet.

These resource-poor, rural and remote communities have fully adopted the Internet Backpacks as core for their community network and consider them community-essential infrastructure. The communities are prepared to pool resources to pay for operating costs going forward, so project sustainability is assured.

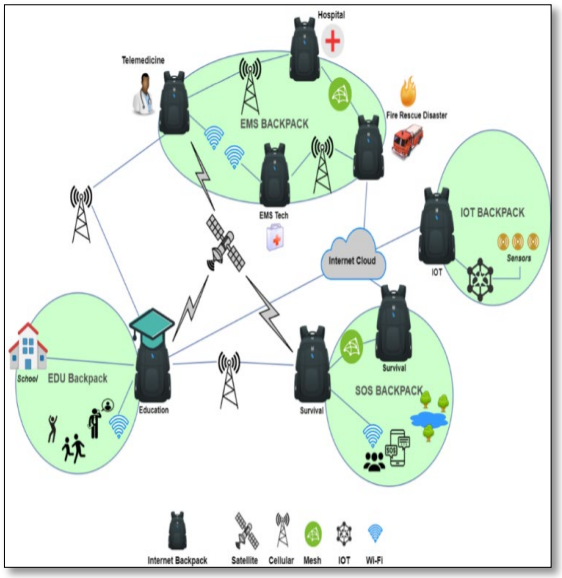
The project has established the objective of sustainable and affordable Internet connectivity, and the local communities have established ownership of the project. Community support and operation of the backpack means that the project will continue as a community led initiative. As such, the project has become institutionalized, thus simplifying replication in other communities. The project teams continue to engage in conversations with the communities and receive important feedback on improvement and augmentation of the Internet Backpack technology.

3.1 Strengthening Health Systems Globally: Deployment of the Internet Backpack

A strong health system is critical to population health as it is the primary mechanism through which health services are delivered. A functional health system ensures that preventable services and health promotion services are provided for all, and especially for the most vulnerable members of societies.[1] Functioning health systems can address fundamental issues that are determinants of morbidity and mortality. Strong health systems necessitate capacity building in planning, budgeting and management at municipal and national levels.

Governments are increasingly prioritizing funding for telemedicine-related and other technology-based Internet healthcare infrastructures.[18,19,20] Typically, these infrastructures only reach as far as

connectivity permits, excluding rural, remote, and low-income regions. The Internet Backpack enables community residents to share advanced traffic-controlled and therefore also possibly limited bandwidth and edge infrastructure of not only connectivity but also portable solar panel-produced energy. This may be used for health, education and disaster response and other Internet access purposes as determined by community partners, government, and other stakeholders. The modular design permits cross-community coordination and resource-sharing to create ad hoc mesh networks across multiple Internet access paths, with computation-intensive activities undertaken in the cloud to conserve scarce edge resources whenever possible, as Figure 1 illustrates.



Source: Courtesy IMCON International, U.S. Patent 11,272,400 B2[21]
Figure. 1. Cognitive Cloud to Edge Traffic Control.

The recent outbreaks of regional epidemics and global pandemic, their persistence, and the ensuing loss of life and disruption of economic and other activities demand more coordinated initiatives to fight diseases, including in the world's most remote regions. These initiatives include global collaboration between private and public sectors, health systems strengthening and enhancement of health capacities. Governments, public health officials, researchers, private and public partners, and other interest groups around the world can more effectively coordinate efforts to mitigate the recurrence of the COVID-19 pandemic and occurrence of other pandemics. These partnerships should work to strengthen international, national and local communities' disaster response systems that address the health needs of populations. Doing so would require integration within a global response network with high level Internet connectivity across populations.

At the peak of the pandemic, as the total numbers of people infected with COVID-19 remained high, efforts to reduce its spread included multiple products in development. Several vaccines have been developed and other potential therapeutic products remain in the pipeline. In addition to vaccine and drug development, a primary preventive measure is to reduce exposure. As countries continue to prioritize vaccines, they should also prioritize strengthening primary healthcare services for health promotion and disease prevention activities and coordination of healthcare delivery. The use of technology can be important in achieving the goal of health systems strengthening.[22] Healthcare

technologies were increasingly used during the pandemic, especially in more industrialized nations. The lack of these technologies in poorer and less developed nations (primarily in the global south) contributed to disproportionately higher COVID-related morbidity and mortality rates in these countries. In this project, the team contributed to the goal of health systems strengthening through the use of the Internet Backpack as a tool to disseminate health information about COVID-19 at the community level, in underserved communities.

It is important that healthcare technological innovations are made available for widespread use among populations. As a socio-technological innovation, the Internet Backpack has the potential to contribute to reducing the spread of infectious diseases. The Internet Backpack can be deployed as an early warning and monitoring system during outbreaks of disease and can provide governments with a cost-effective approach to manage pandemics. Given the urgent need to reduce the spread of infectious diseases, the Internet Backpack also contributes to the potential to halt pandemics because it provides community members in rural, remote and other underserved locations with a tool to send early warning signals to global audiences of new developments. The Internet Backpack's technology can be deployed to develop effective health interventions that improve health outcomes, especially in resource-scarce settings. As our project in Costa Rica theorizes, governments can invest in mobile health technologies to connect key health informants in rural, remote and other areas to regional offices and health facilities for the collection of data and can thus use the Internet Backpack to augment their capacity in data collection and analysis. [15]

4 Conclusion

The transmission of diseases is a nationally and globally destabilizing force which damages economic, social, political and other infrastructures. The spread of COVID-19 around the world has been against the background of increasing socio-economic instabilities, political unrest, hypermobility, environmental degradation, and inequities within and between nations. COVID-19 continues to expose the de-investment in public health, including in the world's most affluent countries. The Internet Backpack can be used to overcome human resource shortages by making use of skilled health workers at the local level to extend health coverage, disseminate life-saving health information, improve quality of life and develop community health partnerships. It can thus enhance the capacity of healthcare professionals and strengthen health systems. As our research shows, the Internet Backpack can function as a liaison between health professionals and the communities they serve, thereby maintaining a high quality of service at a lower cost. In short, it represents a long-term and low-cost tool to strengthen health systems in resource poor settings.

COVID-19 has shown the importance of digital access in healthcare. Access to the Internet can improve health systems' efficiency and efficacy, and consequently improve population health outcomes and reduce health disparities within and among nations. It is important to evaluate the contributions of cognitive systems and community network technologies such as the Internet Backpack for health policymakers considering implementing technology innovations to increase access to public health information and services.[21] The Internet Backpack can be used as a mechanism to reach underserved populations in remote and hard to reach communities, and to reduce the digital gap. Access to the Internet is an essential component of access to health. It is user-friendly (elementary school children can use it).

With the decimation of populations by the pandemic and its exponential spread across nations, the international community continues to recognize the need to strengthen health systems. Many governments have increased health spending in their national budgets, with the recognition that better health outcomes positively impact their social and economic prosperity. As the international community and national governments allocate resources to continue to fight the pandemic and to strengthen health systems, it is important to prioritize funding for mechanisms that increase public awareness of the threat that infectious diseases pose and ways to prevent their spread and mitigate their impact.[2] It is also important to prioritize building healthcare infrastructures to strengthen the core architecture of health systems, which can then more readily respond to the pandemic, other emerging or re-emerging diseases, and to more diverse health challenges. Health security improves population well-being, economic and political stability, trade, tourism, and access to goods and services.

On a longer-term basis, substantial strengthening of the World Health Organization's Global Outbreak Alert and Response Network is needed, as is international support for strengthening of regional and national partners for the public health, clinical and laboratory networks required for such a response. Obtaining rigorous clinical and public health data should continue to be prioritized as a global public health goal. This project shows that deployment of the Internet Backpack contributes to achievement of this goal. This project contributes to the discussion on the use of technological innovations in healthcare. In the long-term, it is also important to address the social determinants of health globally.

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