Contact Tracing Apps: A Comparative Analysis of Canada's COVID Alert and India's Aarogya Setu based on Persuasive System Design Model*

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Abstract. Few months into the pandemic, contact tracing apps (CTAs) were launched by national and provincial governments worldwide to help in curbing the spread of COVID-19. However, their adoption has been slow and low. This calls for their evaluation using established design frameworks with a view to finding ways to improve their design, make them more effective and increase uptake. Given the endemic potential of COVID-19, CTAs may continue to be relevant in our lives. In this paper, we compared the CTA of a high-income, developed, less populous country (Canada – COVID Alert) with that of a middle-income, developing, populous country (India - Aarogya Setu) to uncover design lessons that designers and sponsors of both apps can learn from each other to improve future iterations. We used the Persuasive System Design (PSD) Model (a design, implementation, and evaluation framework) to assess the similarities and differences of both apps. We found that the Indian app supports more persuasive features from the PSD model than the Canadian app. For example, while the Indian app supports persuasive strategies such as Personalization, Reminder, Social Role, Normative Influence and Social Location Monitoring, the Canadian does not. We discuss the findings and made recommendations for future CTA design.

Keywords: COVID-19 · contact tracing app · exposure notification app · COVID Alert · Aarogya Setu · persuasive design · persuasive strategies.

1 Introduction

In the first quarter of 2020, the world woke up to a pandemic, which has been raging for over two years, with no end in sight. The recent emergence of omicron (one of the latest variants of COVID-19) has increased worries in the wider population, especially among the middle-aged and older Canadian populations, which have been hardly hit by the pandemic in terms of death toll [19]. Regardless of

* Persuasive 2022, Adjunct Proceedings of the 17th International Conference on Persuasive Technology.

an individual vaccination status, pessimism and uncertainty continue to grow in Canada and globally. For example, 47% of Canadians are uncertain about the future, with 28% thinking the worst is yet to come compared with 26% who think the worst is behind them [19]. So far, as of January 21, 2022, 345,737,867 cases and 5,583,860 deaths had been reported [22]. The onset of the pandemic resulted in the launching of contact tracing apps by many national and provincial governments around the world to curb the spread of the virus. However, the uptake of these apps has not been very encouraging [20]. Factors associated with low adoption rates include trust [4][5], privacy concern [2][3], utility, minimalist design among others [17]. Despite the low uptake, most empirical studies, according to a recent systematic review published in mid-2021, have reported favorable effects of CTAs on reproduction rate, total number of infections, and mortality rate [23]. This suggests that CTAs will continue to be useful as long as COVID-19 stays with us. Consequently, there is a need for researchers and developers to continue to find ways to make them more effective in slowing the spread of COVID-19 from person to person. In the current study, we compare the design of two different national CTAs published on the Apple and Google app stores with a view to eliciting helpful design lessons which stakeholders of both apps can learn from each other and leverage in future iterations. The apps include Canada's COVID Alert and India's Aarogya Setu. Apart from the characteristic difference between both countries (e.g., socially, culturally, economically, and demographically) one main reason for choosing their respective apps is that they are markedly different in their design, features, and user experience. For example, while COVID Alert is minimalist in its design (and thus provides limited features), Aarogya Setu is robust (offers multiple features including vaccine registration) [30]. We used the Persuasive System Design (PSD) Model to assess the similarities and differences of both apps [35]. The PSD model is a commonly and widely used design, implementation, and evaluation framework [24]. It has been successfully employed to design, and evaluate persuasive systems such as BEN'FIT (a fitness app) [26] and Netflix (a video streaming service) [25], respectively.

2 Background

We provide an overview of the Covid Alert and Aarogya Setu apps, and the PSD model employed in carrying out the comparative analysis.

2.1 Overview of COVID Alert and Aarogya Setu

Table 1 provides a summary of the key characteristics of COVID Alert and Aarogya Setu, including number of installs, rating, privacy design, and cost.

COVID Alert is the official CTA of the Canadian Government, launched on July 31, 2020 to curb the spread of COVID-19. Available in English and French, it can be downloaded from the Google and Apple app stores by Canadian residents in the Northwest Territories, Prince Edward Island, Nova Scotia, Quebec, Manitoba, Saskatchewan, New Brunswick, Ontario, and Newfoundland and

Table 1. Key characteristics and metrics of COVID Alert and Aarogya Setu as of February 03, 2022. *Relative to national smartphone adoption. **The total cost for developing the app is equally split between the Apple and Google versions. Cent: Centralized, Decent: Decentralized, N/A: Not Available.

Metric	**Apple**		**Google**		**Overall**	
	Canada	India	Canada	India	Canada	India
# installs	N/A	N/A	1,000,000+	100,000,000+	6,849,624	214,000,000
Install rate*	N/A	N/A	3.10%+	16.66%+	21.21%	35.66%
# ratings/ reviews	4,992	295,200	9,029	1,638,940	14,021	1,934,140
Star rating	4.30	4.10	3.20	3.20	3.75	3.65
Privacy design	Decent	Decent & Cent	Decent	Decent & Cent	Decent	Decent & Cent
Cost** [36]	C$ 10M	C$ 0	C$ 10M	C$ 0	C$ 20M	C$ 0

Labrador [1]. The app uses the Google/Apple Exposure Notification (GAEN) application programming interfaces and strong privacy measures to protect the user data it collects. It uses Bluetooth for phone-to-phone communication and, hence, does not track the user's location or collect personal identifiable information such as name, contacts, address, or health information. The app comprises four key interfaces: no-exposure status, exposure status, diagnosis report, and self-assessment. The first three interfaces are described in detail in [17][18].

Aarogya Setu (meaning "the bridge to health" in Sanskrit) is the official CTA of the Indian Government, launched on April 2, 2020 [7]. It was developed by the National Informatics Centre (NIC) under the Indian Ministry of Electronics & Information Technology (MeiTY). The app is available in a total of 12 languages (English, Tamil, Hindi, Telugu, Kannada, Malayalam, Punjabi, Bengali, Oriya, Gujarati, Marathi, and Assamese). This list is being expanded to include more Indian languages in the future [28]. The app supports both iOS and Android platforms, and can be downloaded by anyone across the 29 states of India or even abroad. The app utilizes Bluetooth and GPS location-based information to provide notifications to the user based on their interactions with others. The GPS and Bluetooth sensors enable the app to track user movement, and interact with smartphones with the same app installed to generate notifications utilizing its databases and algorithms. There is an in-built self-assessment feature in the app that can be used to evaluate users' level of risk by answering a few questions related to their health and symptoms. The data collected through the app is only shared with the Government of India without being disclosed to any third party [16]. The app consists of four sections: "Your Status", "COVID Updates", "Vaccination", and "COWIN", which provide information regarding the user's risk and vaccination status. Moreover, there is a provision for users to download their vaccine certificates by directly accessing the COWIN vaccination portal.

2.2 Persuasive System Design Model

The PSD model is a framework used to design, implement and evaluate behavior change support systems [35]. The PSD model is composed of four categories of persuasive strategies, including primary task support, dialog support, social support, and system credibility support. The primary task support category of persuasive strategies help users to carry out or accomplish a target behavior easily and effectively. The dialog support category motivates users to accomplish the target behavior through feedback and interaction with the system. The social support category motivates the user to accomplish the target behavior through social influence. Finally, the system credibility support is aimed to make the system appear credible and trustworthy to the user. Basically, each of the four categories comprises seven persuasive strategies. However, we extended the primary task and social support categories based on the elicited strategies from the apps. We provided a definition of each of the strategies in each category in the results section, in which we presented the strategies elicited from both apps.

3 Related Work

There is limited research on the persuasive design of CTAs [9]. In this review, we covered relevant studies based on Aarogya Setu and COVID Alert. Raman et al. [31] conducted a study in 2021 to assess the performance of CTAs on Google Play Store by focusing on key metrics. They found that the ratings and reviews of both apps were high and relatively higher than most apps from other countries. The Canadian app had an average rating of 4.376 stars and the Indian app 3.872 stars [31]. Regarding privacy and data protection, they found that the Canadian app was rated high, and the Indian app was rated medium. However, regarding transparency rights, the Indian app was rated high, and the Canadian app was rated medium. Oyibo and Morita [17] published a conceptual paper, in which they proposed persuasive features such as Self-Monitoring, Social Learning and Normative Influence from the PSD model to improve the effectiveness of COVID Alert. Next, Oyibo and Morita [12] evaluated the persuasive design of COVID Alert, compared with the control design. They found that equipping the app with Self-Monitoring (of exposure level) and Social Learning (about how many others are reporting their diagnosis) can increase adoption among non-adopters by over 10%. Overall, they found that the persuasive design of the app is more likely to be adopted by non-adopters than the control design. Kodali et al. [13] carried out a thematic analysis of user reviews of Aarogya Setu on Google Play Store. They found that over half of the users (56%) assigned 4- and 5-star ratings to the app (signifying higher satisfaction), and about one-quarter of the users (27%) assigned 1- and 2-star ratings to the app (signifying lower satisfaction). They found that 80% of the reviews were on user acceptance, 72.8% on app usefulness, and 62.2% on app features. They also found that users were concerned about user privacy, data security, software bugs, and the reliability of self-reported self-assessment. However, none of the reviewed studies compared two or more CTAs in terms of persuasive design. The aim of this paper is to bridge this gap.

4 Method

Three researchers (KO, SS, KK) were involved in the evaluation of the COVID Alert and Aarogya Setu apps using the PSD model. COVID Alert was assigned to SS, who was in Canada and using the app, to study and elicit the apparent persuasive strategies using the list and definitions shown in the PSD model (see Table 2 to Table 5). Similarly, Aarogya Setu was assigned to KK, who was staying in India at the time and using the app to evaluate. KO, a senior and more experienced researcher, played an oversight role in the weekly discussions over a one-month period (between January 5, 2022 and February 6, 2022), In the weekly meetings, which occurred on Microsoft Teams, all three researchers discussed, critiqued, verified, and refined the strategies elicited from both apps.

Moreover, to reduce the bias of the researchers and supplement their assessment of the PSD's credibility support strategies, we asked 21 participants resident in India (n = 10) and Canada (n = 11) to provide their opinion on both apps. Due to the exploratory nature of the study, we did not seek ethics approval. We believed that having the opinions of Aarogya Setu and COVID Alert users would help increase the reliability of our assessment of the credibility support strategies. We focused on four credibility-related strategies (Liking, Trustworthiness, Expertise, and Surface Credibility), which we considered subjective. All of the four constructs were measured using Perceived Aesthetics, Perceived Trust, Perceived Expertise, and Perceived Credibility, respectively, which were adapted from the extant literature (see Appendix for the questionnaire).-Perceived Aesthetics was measured using two subdimensions (Classical and Expressive), and Perceived Credibility was measured using two subdimensions (Honesty and Reputation) on a Likert scale ranging from "Strongly Disagree - 1" to "Strongly Agree - 7". The Canadian/Indian groups included 7/7 males and 4/3 females. The mean age was 24/32 years old. Both groups comprised 8/6 younger participants and 3/4 older participants, with the latter group defined as above 25 years old. Both groups included 6/1 Apple users and 5/9 Android users.

5 Results

We present the results of the exploratory study and the persuasive strategies elicited from both apps. First, we conducted the reliability test for the six measured constructs, which was based on McDonald's coefficient omega (ω) given the non-normality of the data. The results showed that the reliability requirement for each construct ($\omega > 0.7$) was met [39]. Figure 1 shows the plots of all six constructs on a 7-point scale. Similar to Raman et al.'s [31] guideline for rating CTAs on the app store, we categorized the rating of the credibility support constructs into three levels (1.00-3.99: low, 4.00–4.99: medium, 5.00-7.00: high). Overall, Aarogya Setu was rated higher than COVID Alert. For the Indian group, all of the constructs, except Classical Aesthetics, have high ratings. Moreover, for the Canadian group, all of the constructs have medium ratings. We performed a 4-way ANOVA, which shows that there is an interaction between age, gender and app $[F(65, 1) = 5.25, p < 0.05]$. Within the

younger group, a further two-way ANOVA based on app and gender shows there is a main effect of app [$F(66,1) = 20.81, p < 0.0001$], with Aarogya Setu (M = 5.35) rated higher than COVID Alert (M = 3.93). Within the older group, a further two-way ANOVA shows there is an interaction between app and gender [$F(31,1) = 25.48, p < 0.0001$]. Within older males, there is a main effect of app [$F(18,1) = 4.63, p < 0.05$], with Aarogya Setu (M = 6.07) rated higher than COVID Alert (M = 5.43). However, within older females, there is a main effect of app [$F(13,1) = 23.67, p < 0.001$], with COVID Alert (M = 5.07) rated higher than Aarogya Setu (M = 3.19). Table 2 to Table 5 show the identified persuasive strategies for both apps and the rationale for their elicitation. Regarding primary task support, two-third and three-quarter of its strategies were elicited from COVID Alert and Aarogya Setu, respectively. Regarding dialog support, three-fifth and six-seventh of its strategies were elicited from COVID Alert and Aarogya Setu, respectively. Regarding social support, zero and half of its strategies were elicited from COVID Alert and Aarogya Setu, respectively. Finally, regarding credibility support, three-fifth and six-seventh of its strategies were elicited from the COVID Alert and Aarogya Setu, respectively.

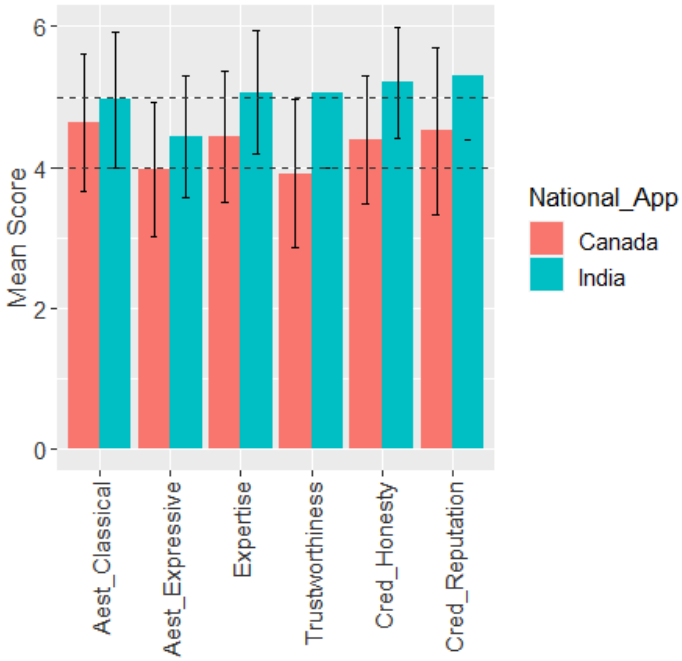

Fig. 1. Mean rating of credibility support constructs. Vertical bar means 95% confidence interval. Below the bottom horizontal line indicates low rating, in between both horizontal lines indicate medium rating, and above top line indicates high rating.

Table 2. Primary task support persuasive strategies elicited from COVID Alert (66.67%) and Aarogya Setu (77.78%). "XXX" means not implemented in the app..

Strategy	App	Description of Implementation
Reduction: Break down complex behavior into simple steps.	Can	XXX
	Ind	XXX
Tunneling: Guide the user in a predetermined fashion to accomplish the target behavior.	Can	XXX
	Ind	Provides a self-assessment tool, which asks users questions about their symptoms to reach a certain risk level, and recommends useful health instructions.
Self-Monitoring: Allow the user to track or monitor their behavior over time.	Can	Keeps track of the user's COVID-19 exposure status through an alert.
	Ind	Keeps track of the user's COVID-19 risk level through self-assessment and exposure status through an alert.
Tailoring: Tailor information/interfaces based on group attributes.	Can	Supports English and French to allow groups speaking either language to use the app.
	Ind	Supports 12 languages to accommodate different tribes.
Personalization: Tailor in real time user interfaces/information based on user interactions.	Can	XXX
	Ind	Provides localized information based on the area users are currently living or residing in, e.g., number of cases within a given region.
Customization: Allow the user to customize the system to suit their preferences.	Can	Allows users to select province (based on where they are) and choose between English and French.
	Ind	Allows users to choose from twelve language options.
Simulation: Show a link between behavior cause and effect.	Can	XXX
	Ind	XXX
Rehearsal: Rehearsal of behavior in app before execution in real life.	Can	XXX
	Ind	Provision of a self-assessment feature to assess user safety and take measures in real life as necessary.
Integration: Integrate multiple systems for related purposes into a single system to increase utility.	Can	XXX
	Ind	Integrates different systems into the same app, e.g., exposure notification, diagnosis reporting, vaccination appointment booking, vaccination certificate download, vaccination status display, online consultation, etc. [6].

Table 3. Dialog support persuasive strategies elicited from COVID Alert (57.14%) and Aarogya Setu (85.71%). "XXX" means not implemented in the app..

Strategy	App	Description of Implementation
Praise: Praise the user for performing behavior using textual, visual or audio feedback.	Can	Gives the user a thumbs-up for currently not being exposed to COVID-19. [17].
	Ind	XXX
Reward: Give the user tangible and virtual rewards for performing behavior.	Can	XXX
	Ind	Provides the user with refined contact tracing results if they share their data (e.g., location, contacts, diagnosis, risk level) with the government [28].
Reminder: Send the user reminder to increase the odds of performing behavior.	Can	XXX
	Ind	Provides reminder notifications to users to complete their self-assessment.
Suggestion: Provide the user just-in-time suggestions to facilitate performance of behavior.	Can	Provides suggestions to isolate, upon entering QR code for testing positive.
	Ind	Provides information on the importance of following COVID-19 safety guidelines such as social distancing and masking. Gives the user specific suggestions, e.g., self-isolate, after taking the self-assessment test.
Similarity: Support features and elements that remind the user of themselves.	Can	Provides two languages (English and French) to match the user's preferred language.
	Ind	Provides 12 languages to match the user's preferred language.
Liking: Make the system aesthetically pleasing and appealing to increase engagement.	Can	*The app is moderately liked based on our exploratory study (see Figure 1).*
	Ind	*The app is moderately liked based on our exploratory study (see Figure 1).*
Social Role: Support social roles to motivate the user to do expected behavior that fits their role.	Can	XXX
	Ind	(1) Supports a self-assessment tool, which allows the user (patient) to evaluate their COVID-19 exposure status and/or risk level by responding to certain predefined questions from the app (representing a health professional). (2) Allows a parent to monitor their child's COVID-19 exposure and/or risk level.

Table 4. Social support persuasive strategies elicited from COVID Alert (0%) and Aarogya Setu (50%). "XXX" means not implemented in the app..

Strategy	App	Description of Implementation
Social Learning: Allow the user to observe others perform the behavior to motivate them to imitate it.	Can	XXX
	Ind	Tells the user, within a specified radius, how many people have completed the self-assessment in the past 24-48 hours. Provides a link to a government vaccine database which gives detailed information on vaccination statistics.
Social Comparison: Allow users to compare their behaviors with others'.	Can	XXX
	Ind	XXX
Normative Influence: Employ social pressure (the need to be liked and accepted) to motivate behavior.	Can	XXX
	Ind	Allows family members to monitor their risk level, thereby putting pressure on each family member to follow the norms (COVID-19 safety guidelines).
Social Facilitation: Make the user aware of the performance of the behavior by others at the current time.	Can	XXX
	Ind	Tells the user, within a specified radius, how many people are currently registered on the app, and using the app.
Cooperation: Allow users to work together to achieve a collective goal and/or reward.	Can	XXX
	Ind	XXX
Competition: Allow users to compete, e.g., by displaying their performance on a leaderboard.	Can	XXX
	Ind	XXX
Recognition: Publicly recognize the user to motivate future performance of the behavior.	Can	XXX
	Ind	XXX
Social Location Monitoring: Allow the user to monitor a given location/region to assess their risk.	Can	XXX
	Ind	Shows how many users in a particular radius have been assessed as high risk in the past 24-48 hours.

Table 5. Credibility support persuasive strategies elicited from COVID Alert (57.14%) and Aarogya Setu (85.71%). "XXX" means not implemented in the app. [*continued next page*]

Strategy	App	Description of Implementation
Trustworthiness: Make the system trustworthy by fostering transparency, security, and privacy.	Can	Provides privacy policy (e.g., personal identifiable information will not be collected) to foster trust. The source code is made available to the public to increase transparency. [*The app is perceived as medium in trustworthiness based on our exploratory study (see Figure 1).*]
	Ind	(1) Provides privacy information in the FAQ section of the app and via links to external websites. (2) The source code is made available to the public to increase transparency. [*The app is perceived as high in trustworthiness based on our exploratory study (see Figure 1).*]
Expertise: Show that the system is developed by technical experts aside from competence, professionalism, and innovation.	Can	*The app is perceived as medium in expertise based on our exploratory study (see Figure 1).*
	Ind	Mentions in Google Play Store the app is developed by National Informatics Centre under the Ministry of Electronics & Information Technology of the Government of India. [*The app is perceived as high in expertise based on our exploratory study (see Figure 1).*]
Surface Credibility: Foster believability through system look and feel and offering accurate information.	Can	*The app is perceived as medium in credibility (honesty and reputation) based on our exploratory study (see Figure 1).*
	Ind	*The app is perceived as high in credibility (honesty and reputation) based on our exploratory study (see Figure 1).*
Real-world Feel: Design the system to mimic real-world processes and user experience.	Can	XXX
	Ind	(1) The self-assessment tool mimics a real-life session with a healthcare professional. It uses a picture of a nurse and interactive questions to guide the user to arrive at a particular risk level. (2) The app allows the user to show or share their vaccination status with others via social media channels. This allows users to present or show their vaccination status before meeting with someone or gaining access to premises. (3) The app contains a media/news section, which keeps the user updated on the COVID-19 situation and events. (4) The app also lists helpline numbers which provide users a chance to talk to a real person and present their concerns. (5) The app has a QR Code scanning functionality which allows users to easily share their risk level and see others'.

Strategy	App	Description of Implementation
Authority: Use authority-based information to motivate users to adopt and use the app.	Can	XXX
	Ind	The homepage shows a statement from the Prime Minister of India, highlighting the importance of the app and urging people to download it.
Third-Party Endorsement: Show endorsements from respected sources, e.g., through logos.	Can	The about page on the Google Play Store mentions Health Canada indicating it endorses the app. [Usually users prefer health authorities, and not governments, to take on the responsibility of digital contact tracing [21].]
	Ind	Mentions the Ministry of Health & Family Welfare above the user's vaccination status on the homepage.
Verifiability: Authenticate information using third-party sources.	Can	XXX
	Ind	XXX

6 Discussion

We have presented the key performance metrics for COVID Alert and Aarogya Setu (Table 1) and the persuasive strategies we elicited from both apps using the PSD model (Table 2 to Table 5) to gain insight into how they differ.

6.1 Key App Characteristics and Metrics

There are some marked differences between both apps in terms of features, privacy, design, cost, and adoption rate. For example, unlike COVID Alert where most of the features (e.g., privacy and help information) can be found in an external website, Aarogya Setu is mostly self-contained, with most of its features being in-built (e.g., vaccination appointment booking and downloading the certificate). Secondly, while the Canadian app was developed through contracting by Canadian Digital Service [15] for C$ 20 million, the Indian app was developed by in-house IT professionals within the Indian Ministry of Electronics & IT for C$ 0. Thirdly, the Indian app uses a hybrid privacy design (centralized and decentralized), while the Canadian app, due to the strong concerns about privacy in Canada, uses the decentralized approach. Fourthly, while the Canadian app has been downloaded by one-fifth of Canadian smartphone users, the Indian app has been downloaded by one-third of Indian smartphone users. Overall, the Indian app provides its users more utility and value than the Canadian app. This may partly explain why Aarogya Setu has a higher adoption rate, aside from being mandated in some situations in India [7]. Another possible explanation for

the higher adoption of Aarogya Setu is that the Indian population (collectivist) is less likely concerned about privacy and thus more likely to trust the app than the Canadian population (individualist) [26][27], as Figure 1 shows.

6.2 Elicited PSD Strategies

For the Aarogya Setu app, the dialog support (85.71%) and credibility support (85.71%) turn out to be the most implemented categories of strategies in the PSD model, and social support (50%) the least implemented. On other hand, for the COVID Alert app, the primary task support turns out to be the most implemented category of strategies (66.66%), and social support the least implemented (0%). Overall, Aarogya Setu supports more persuasive features (14/31) than COVID Alert (19/31). For example, regarding the primary support category, Aarogya Setu supports Integration and Personalization, but COVID Alert does not. Moreover, both apps support Self-Monitoring. However, Self-Monitoring is only implemented partially. For example, in both apps, users can only monitor their COVID-19 exposure status and/or risk level. With that said, the Self-Monitoring feature can be improved upon, e.g., by tracking/visualizing the number of user's daily contacts (within two meters), which are already stored on the user's phone. Regarding dialog support category, Aarogya Setu rewards the user for sharing their data such as location and diagnosis by allowing them to access more refined contact tracing information – a form of reciprocity). Although COVID Alert does not support any reward system, it uses the Praise strategy (a green-color thumbs up to convey a no-exposure status), while Aarogya Setu uses a green-color scheme for the home screen to indicate the no-exposure status.

Regarding the social support category, Aarogya Setu supports four of the eight strategies (Social Learning, Social Facilitation, Normative Influence, and Social Location Monitoring), but COVID Alert does not support any of the strategies. For example, the "Status Check" feature in Aarogya Setu engenders Normative Influence by virtue of collaborative users not wanting to be exposed to COVID-19 (by following the safety guidelines) in order to be in the good books of one another. A plausible explanation for the lack of social features in COVID Alert is that Canadians, due to their relatively high privacy concerns [14], are unwilling to share their health information with others [26]. It is noteworthy that social strategies such as Normative Influence, elicited from Aarogya Setu, can be made more robust to realize additional social influence strategies. For instance, the "Status Check" feature, which enables family and friends to monitor one another, can be used to foster Social Comparison by allowing the collaborative users to view each other's COVID-19 exposure status, risk level, and even individual number of daily contacts side by side on a joint dashboard [17]. This has the potential of motivating the collaborative parties to stay safe, as they would not want to be the odd one in the group. Finally, regarding the credibility support category, most of the constituent strategies are implemented, with Aarogya Setu (6/7) supporting more than COVID Alert (4/7). For example, in Aarogya Setu, we uncovered persuasive strategies such as Real-World Feel, Authority, and

Third-Party Endorsement, which could improve adoption and usage. For example, Real-World Feel includes supporting COVID-19 symptom self-assessment, sharing of vaccination status with others and on social media, and having access to the latest media updates on COVID-19. Moreover, Third-Party Endorsement is implemented by specifying that the app was developed by the NIC in the app stores and is supported by Ministry of Health and Family Welfare in the app, both of which are reputable IT and health bodies, respectively, in India.

Finally, based on the exploratory study (Figure 1), we found that the Indian group perceived Aarogya Setu as highly aesthetic, professional, trustworthy, and credible ($M \geq 5$), except for the expressive aesthetic subdimension rated medium ($4 < M < 5$). However, the Canadian group perceived COVID Alert as moderately aesthetic, professional, credible, and trustworthy ($4 < M < 5$). These findings may not be far-fetched given the minimalist design of COVID Alert [17][30] and its relatively low adoption rate (21%) compared with Aarogya Setu (36%). The relatively lower ratings of the credibility support constructs among the Canadian group might be due to privacy concerns [8]. Specifically, the interaction analyses showed that, within the younger group, Aarogya Setu ($M = 5.35$) was rated significantly higher than COVID Alert ($M = 3.93$). Similarly, within older males, Aarogya Setu ($M = 6.07$) was rated significantly higher than COVID Alert ($M = 5.43$). However, within older females, COVID Alert ($M = 5.07$) was rated significantly higher than Aarogya Setu ($M = 3.19$). It is noteworthy that these findings are preliminary and need further investigations.

6.3 Recommendations

Based on the results of our comparative analysis, we provide persuasive design recommendations, in addition to the ones provided by Oyibo and Morita [17] in their conceptual paper, to improve future CTA iterations.

Technical Expertise. It is important for the app sponsors to show that the app was developed by reputable technical experts. Although COVID Alert was, in reality, developed by Canadian Digital Service, with BlackBerry providing privacy and security guidance [15], this was not conveyed to the potential user in the app or app stores. The institution that was instead displayed in the app store was Health Canada (a non-technical expert). While CTA research shows that people trust health institutions more than governments and technology companies such as Google and Apple [10][21], from a technology design perspective, it may be beneficial for the app sponsors to demonstrate that the app was created by reputable technical experts in the IT space, just as the India app sponsors did. The sponsors of Aarogya Setu did show on the Google and Apple app stores that it was developed by National Informatics Centre under the Ministry of Electronics & IT of the Government of India, a recognized national institution that supports the Indian Government in delivering information technology services to the people. Canada can learn from India in this area. Better still, both health and technical institutions can be listed as collaborators in the app design. With

that said, there is a need for future research to understand how the provider(s) listed on the app store may influence users' perception and adoption of CTAs.

Integration and Self-Containedness. Using multiple systems (apps, websites, etc.) to access COVID-19 related services such as booking vaccine appointments and displaying vaccination status could be very difficult, especially among older people. Hence, the provision of multiple useful features (e.g., vaccination appointment booking, vaccine certificate download, sharing of vaccination status, display of high-risk users within a certain radius, etc.) in the Aarogya Setu [31] might have increased its perceived persuasiveness and installation (over 200 million), as prior research shows that there is a significant relationship between perceived usefulness and perceived persuasiveness [32]. As reported by Alanzi [29], only few CTAs such as Arogya Setu have integrated various useful features (such as self-assessment, online consultation, support, and access to information) in a single app in order to simplify user access to public services. Canada can learn from this. For example, instead of having different apps (e.g., COVID Alert and Arrive Can) for different but related COVID-19 safety goals, the apps can be integrated. However, we recognize that due to privacy issues and the need to make CTA usage voluntary, the Canadian Government was reluctant and may not be willing in the future to implement or integrate certain useful features. To address this challenge, we recommend a personalized approach rather than a one-size-fits-all be taken. We hypothesize that some Canadian users may be willing to use a version of the app that supports beneficial features (such as appointment booking, online consultation, etc.) that provide utility and value. Users can be given the opportunity to add and remove (uninstall) features as they deem fit. However, there is a need for further research to gain insight into what portion of the population is open to new features and what types of features they expect their ideal app to have.

Complimenting the User for Staying Safe. Praising someone verbally or visually makes them feel good about themselves [37], especially for accomplishing a certain outcome. In COVID Alert, a green-colored thumbs-up icon is used to indicate the no-exposure status of the user, which is a form of praise of the user for remaining safe [17]. The Indian app could also adopt this kind of visual dialog support feedback (Praise) to motivate users to continue following COVID-19 protocols such as social distancing to remain safe and protect their community.

Self-Monitoring. The Canadian app only allows the user to track their exposure status through an alert. We recommend that it allow the user to track their risk level as well through self-assessment within the app just like the Indian app.

Social Influence. Social Influence has the potential to motivate behavior change [38]. Although most Canadians are individualists that like protecting their health data [26], some may want to work together with others in their

family and community to achieve certain health goals. Moreover, there are immigrants, although currently resident in Canada, that still possess collectivist tendencies. Hence, just like Aarogya Setu, it may be beneficial for COVID Alert to have a social version as well. This will enable those who want access to social features such as Cooperation (with family and friends), Social Location Monitoring [17] and chat rooms for sharing and discussing beneficial health information to have a choice. Moreover, Aarogya Setu's social features can be enhanced [38]. However, the effect of social influence in CTAs needs further study.

6.4 Contributions

We made a number of contributions to the growing body of CTA design literature. The first contribution is that we mapped most of the functional features offered by existing CTAs (such as Aarogya Setu) to persuasive strategies using the PSD model. This enables researchers studying CTA design to know when and how a persuasive strategy has been applied. The second contribution is that we expanded the original PSD model by introducing new persuasive strategies that are relevant to CTA design (e.g., Integration in primary task support, and Social Location Monitoring in social support [17]). The third contribution is that we demonstrated how the evaluation of credibility support strategies (such as Liking and Trustworthiness), which can be subjective, can be complemented by user's (or designer's) perception to reduce authors' bias. Prior work in this area (e.g., [25]) often evaluated these strategies from the authors' perspective alone.

6.5 Limitations

The first limitation of the study is that the elicitation of persuasive strategies from both apps was subjective. Thus, the researchers could have failed to identify certain persuasive strategies supported by either app or misidentified strategies due to poor judgement. The second limitation is that the persuasive strategies in the PSD model, employed in evaluating the persuasive design of both apps, is not exhaustive. Future work can employ a more comprehensive framework such as Michie et al. [40]. The third limitation is that the results of the study on credibility support features (Figure 1) was based on a convenience sample (known to the researchers) and the sample size was small. Hence, the findings have to be interpreted with caution and context given that the study was only exploratory. Future work should aim at addressing these limitations.

7 Conclusions

The paper presents a comparative analysis of Canada's CTA (COVID Alert) and India's CTA (Aarogya Setu) using the PSD model as an analytical framework. We found that both apps support some key persuasive strategies (e.g., Self-Monitoring, Similarity, and Third-Party Endorsement) from the PSD model,

with the Indian app supporting more strategies including social influence strategies (e.g., Social Location Monitoring and Normative Influence). Despite both apps supporting a number of PSD strategies, there is room for improving their implementations and incorporating more persuasive strategies in future iterations. Moreover, there is a lot the Canadian app can learn from the Indian app, which is one of the most downloaded CTAs in the world [31], in terms of supporting more features (such as vaccine appointment booking and download of vaccination certificate), which Canadians may consider useful. In our future work, we aim to investigate how the incorporation of some of the persuasive features offered by Aarogya Setu, among others from the PSD model, in COVID Alert may impact its perceived usefulness and user adoption.

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Appendix

Table A. Instruments for measuring four of PSD's credibility support constructs in an exploratory study of COVID Alert and Aarogya Setu.

Construct	**Measurement Items**
Survey Title	Getting Your Opinion on Canada's COVID Alert [India's Aarogya Setu] Contact Tracing App
Overarching Question	We would like you to answer the following questions based on your prior experience with the app.
Perceived Aesthetics (Liking) [32]	Classical Aesthetics (1) The app is visually appealing. (2) The app is clean. (3) The app is pleasant. Expressive Aesthetics (1) The app is fascinating. (2) The app is sophisticated. (3) The app is creative.
Perceived Expertise [33]	(1) The app design reflects competency. (2) The app design reflects experienced developers. (3) The app design reflects expertise. (4) The app design reflects knowledgeable developers. (5) The app design reflects innovativeness.
Perceived Trust [33][34]	(1) The app is trustworthy. (2) I trust the app keeps my best interests in mind. (3) I can depend on the app completely. (4) I can always rely on the app. (5) I trust the information presented by the app.
Perceived Credibility [34]	Honesty (1) The app provides truthful information. (2) The app reflects integrity. (3) The app is highly regarded. Reputation (1) The information provided by the app is believable. (2) The app is credible. (3) The app has a good reputation.