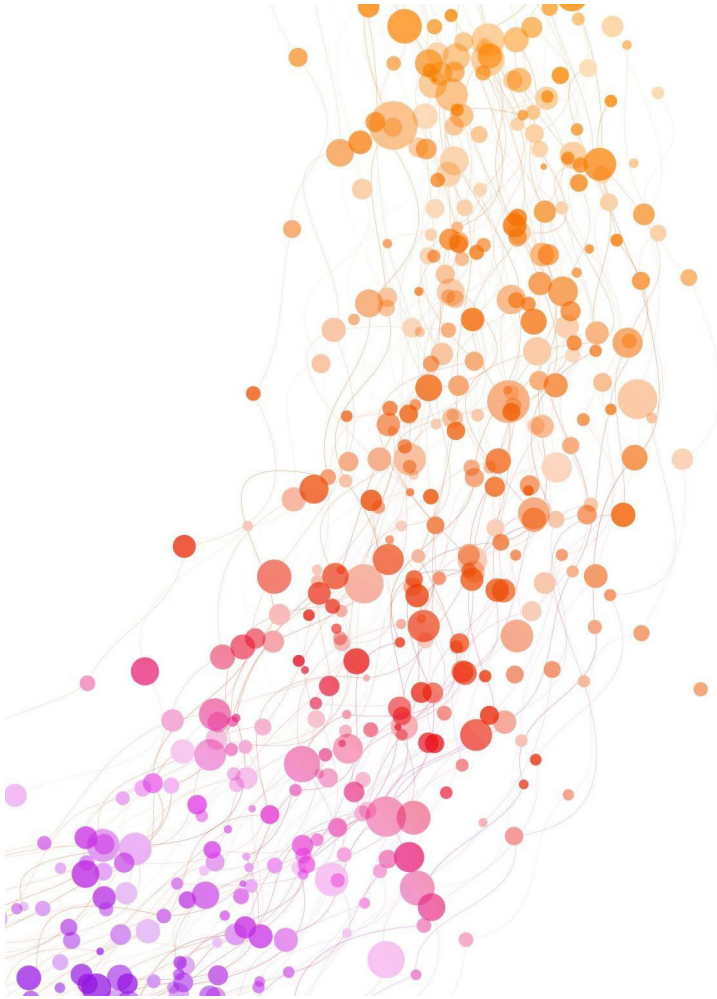
Role of Digital Health interventions and Artificial Intelligence in Vaccine Confidence



Overview

- User Experience and Vaccine Acceptance : India's Covid-19 vaccination journey

- Artificial Intelligence (AI) studies in infodemic management (Vaccine Confidence)

Co-WIN – *A Scalable, Inclusive and Open Platform for Universal Vaccination by 2022*

Co-WIN

Covid Vaccine Intelligence Network

A tech-based platform facilitating the planning, implementation, monitoring, and evaluation of Covid-19 vaccination in India

Guiding Principles

Equitable and Inclusive

Equitable vaccination across multilingual states, with multiple modes for registration to ensure accessibility for all

Single Source of Truth

Unbiased distribution of vaccines through a single source of data to remove information asymmetry and align stakeholders

Evolvability and Scalability

Dynamic architecture capable of evolving and accommodating changes as per circumstances, built for a scale of a billion plus citizens

Feedback and Analysis

Data on vaccination and recording of AEFI helps form data-driven public health policy and evaluate the efficacy of different vaccines

For the Citizens

Advantages for Citizens – *Agency at the core, luxury of choice*

Core Functionalities

Blended Registration
Digital & Offline Walk-ins
Mobile # | Choose from 9 Photo IDs

Track Vaccination Schedule
Guidance on interval between two doses based on vaccine brand

Convenience in Slot Booking
Choose vaccination slot based on convenient time and location

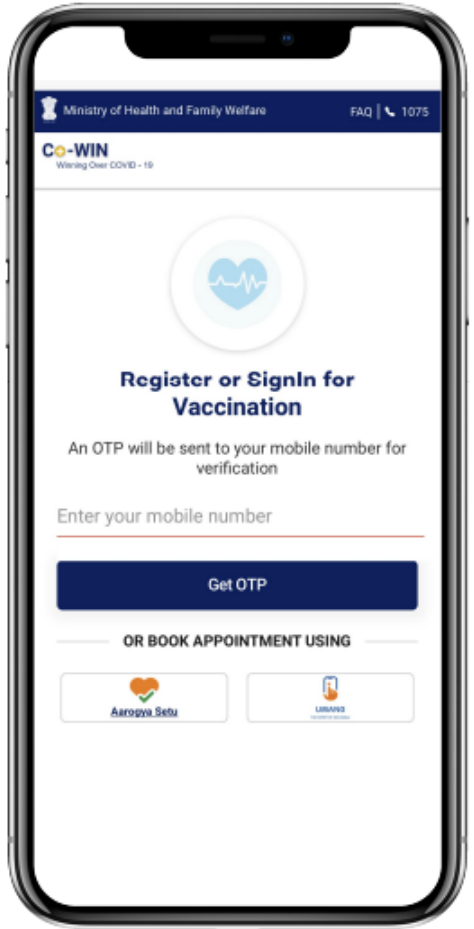
Instant Digital Certificate
Issued post vaccination
Universally authenticable

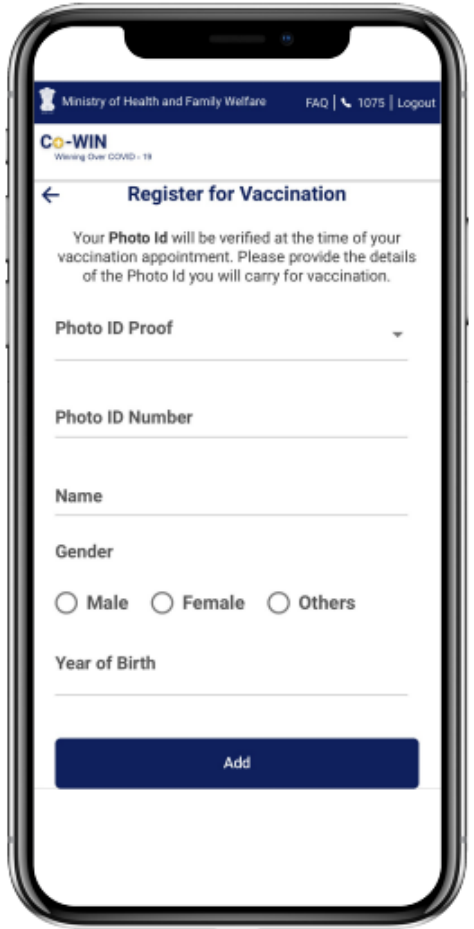
Modes of Registration
- Offline on-site registration
- Online registrations through portal
- Assisted registration through support centres and call-centres

Simplified Access
- Find vaccination centre using maps
- Sign-up with mobile number and verify with a four-digit OTP
- Multilingual – Power of vernacular

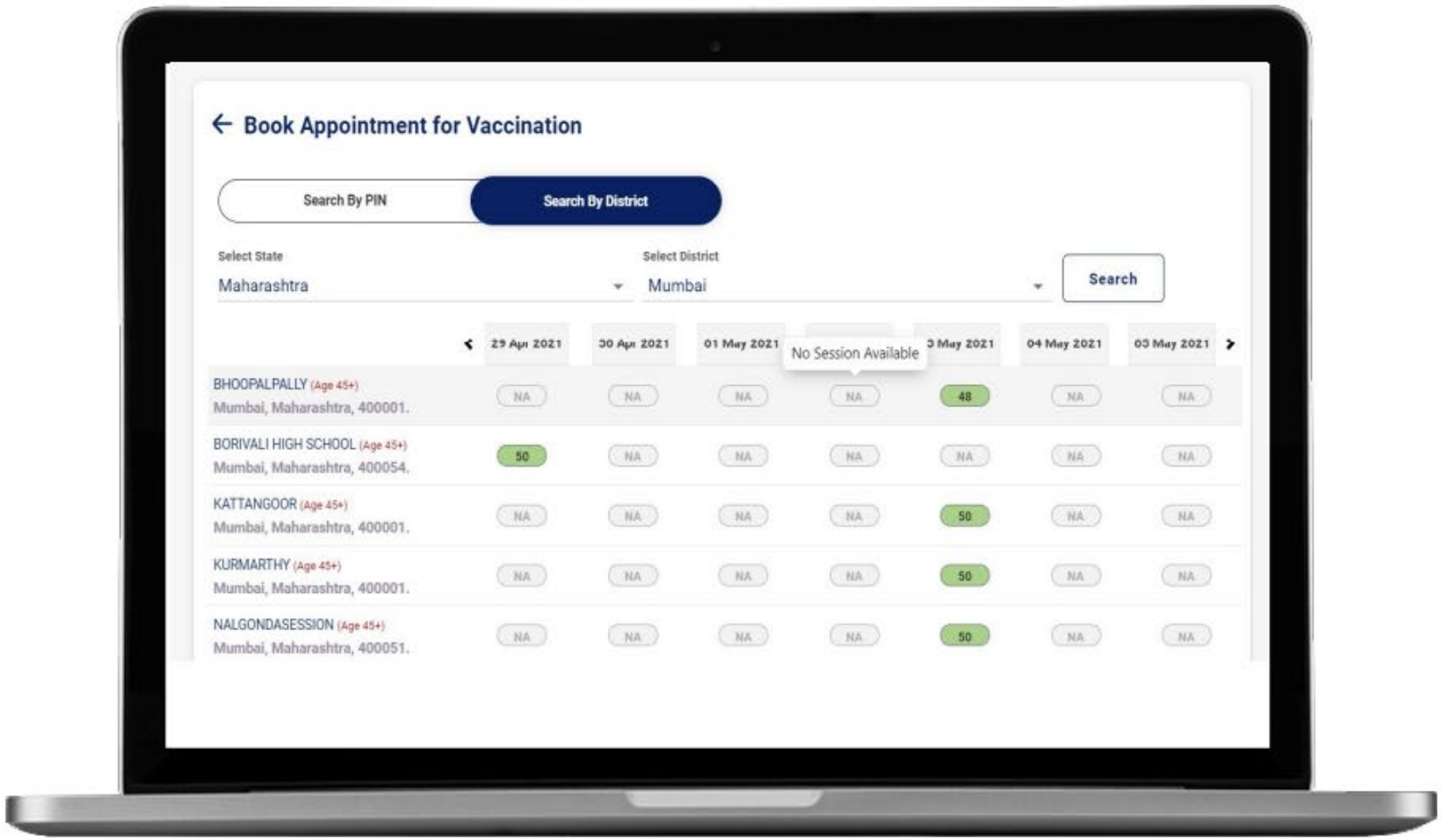
Minimal Data Inputs
- Non-sensitive data inputs
- Required - Name, age & gender
- Multiple photo identification options
- Monosyllabic / single-word prompts

Easy Registration – *Option of 9 photo IDs and 12 languages*

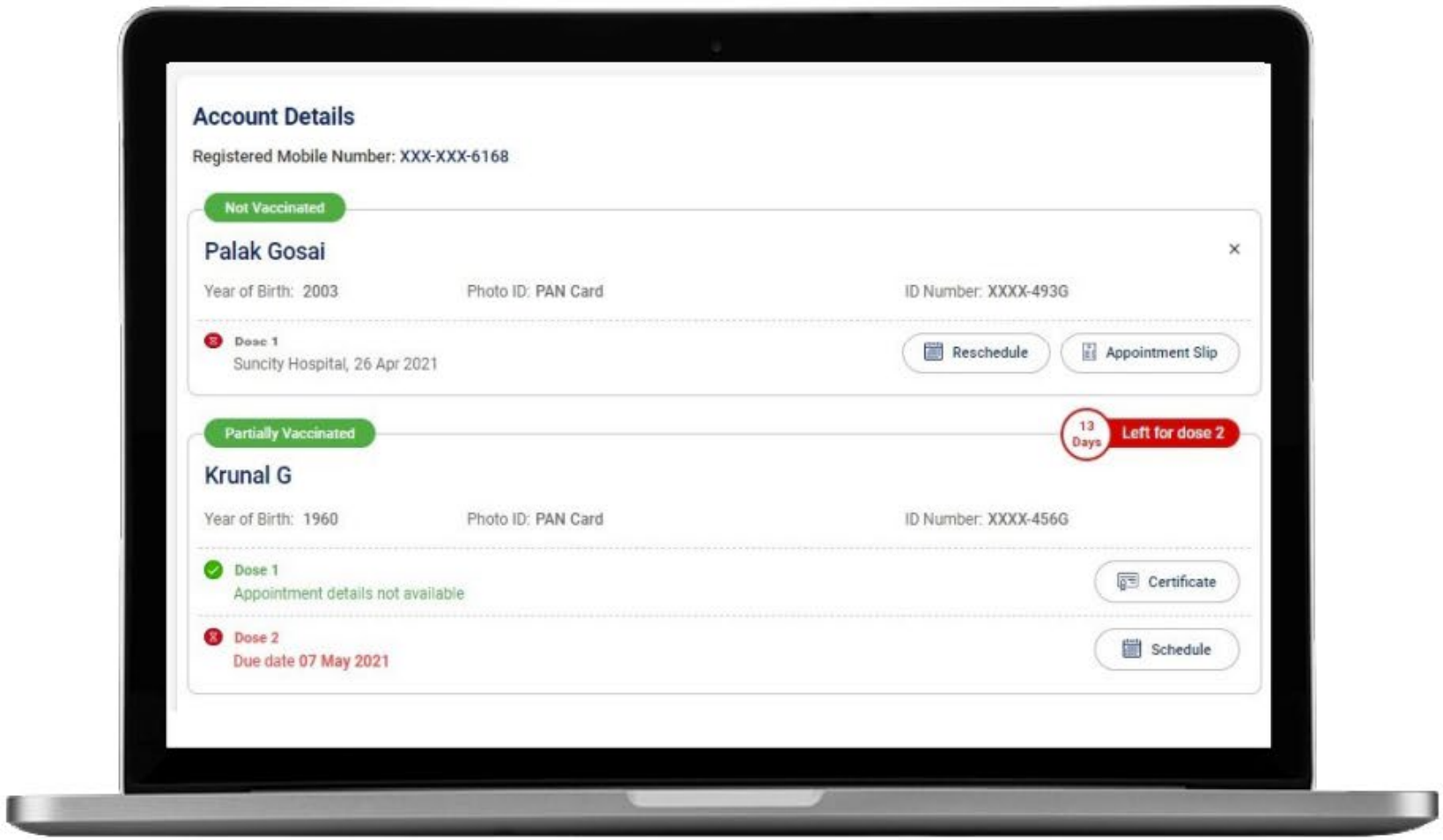




Choice of Time and Location – *Book a vaccination slot as per convenience*

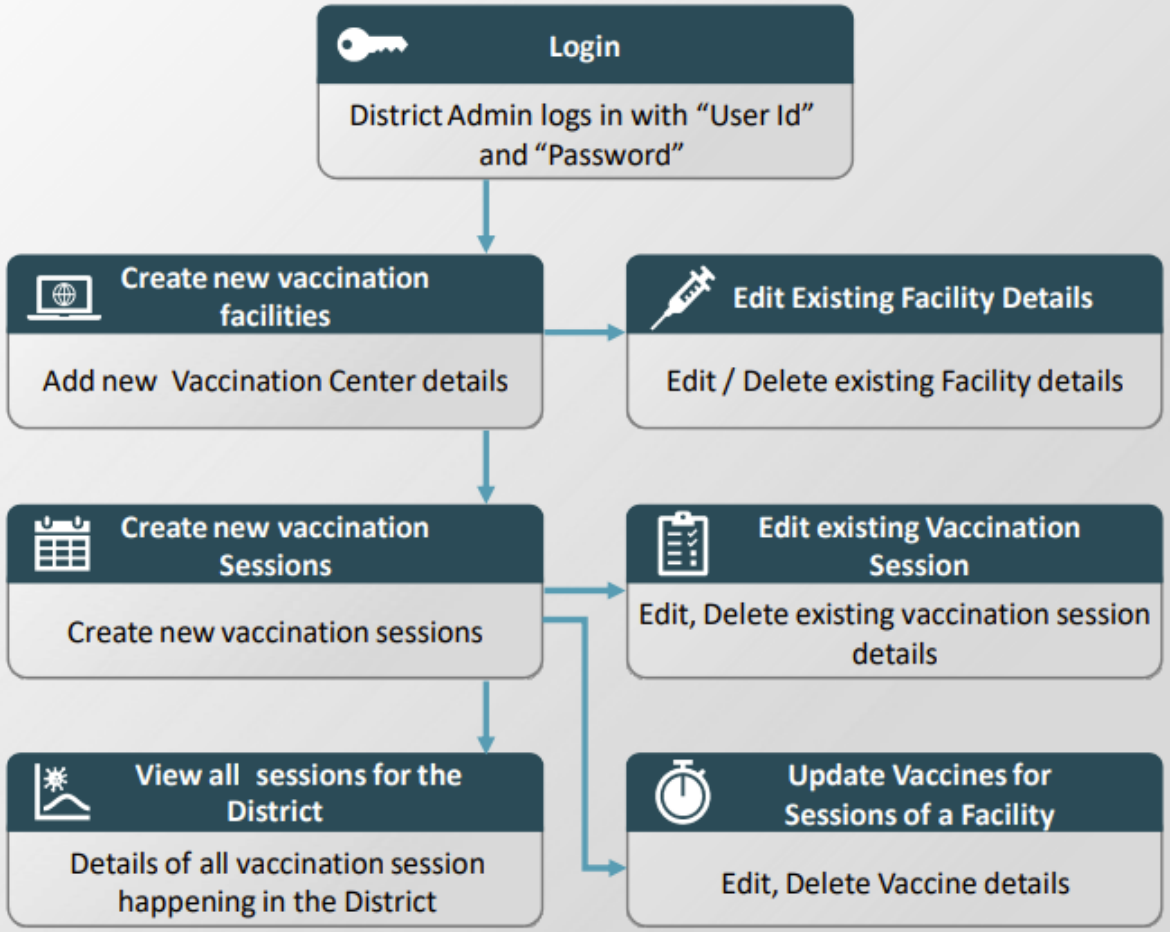


Tracking Vaccination – *Book for up to 4 individuals, check schedule & download certificate*



Advantages for Managers – *Uniform access across private and public, fixed or mobile*

Process Flow



Features for Vaccinators

Vaccine Stock Management
Verify validity of stock supplied
Traceability of each vial of vaccine

Publishing Vaccine Schedules
Declare availability based on stock daily & define quotas for categories

Verification of Citizens
Authenticate at point of vaccination Upload records of HCWs/ FLWs

Realtime Dashboards
Analytics provided to view all sessions at a vaccination facility

Advantages for Policy Makers – *No information asymmetry and alignment of departments*

Single Source of Truth

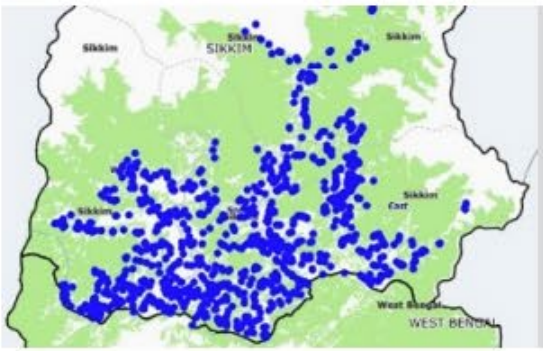
Aligns all stakeholders to prevent any form of rent-seeking and truly making each stakeholder accountable for their actions

Tracking AEFI for Vaccines

Allows recording of AEFI to form data-driven public health policy and evaluate the efficacy of different vaccines

Efficient Tracking of Certificates

Providing a reference point post first dose to guide citizens to follow the vaccination schedule and get the same second dose as first



Evaluating Geographical coverage

Facilitates coverage at a granular geographical level that helps get a view of each district at a state level to evaluate progress of vaccination

Inclusivity

Multiple modes of registration in offline walk-ins, online and assisted through help centres and call centres ensure access for all

C-WIN
Winning Over Covid-19

VERIFY CERTIFICATE FAQ

Total Vaccination Doses

2,20,67,47,566

Dose 1	Dose 2	Precaution Dose
1,02,74,19,269	95,19,86,157	22,73,42,140

Sites Conducting Vaccination

107

Government	Private
66	41

Total Registrations

1,10,93,69,270

Age 12-14	Age 15-17	Age 18-44	Age 45+
4,21,08,018	6,29,27,726	63,38,27,778	37,04,48,156

AI and Infodemic Management (Vaccine Confidence)

- Evidence and gap map of interventions for infodemic management during health emergencies: a case of COVID-19 pandemic
- Sponsored by by the World Health Organization
- Systematic review and mapping of the studies in infodemic management in a matrix of interventions and outcomes
- Highest evidence (among non-impact studies) was for Artificial Intelligence (AI) studies (n=430 [out of 983])

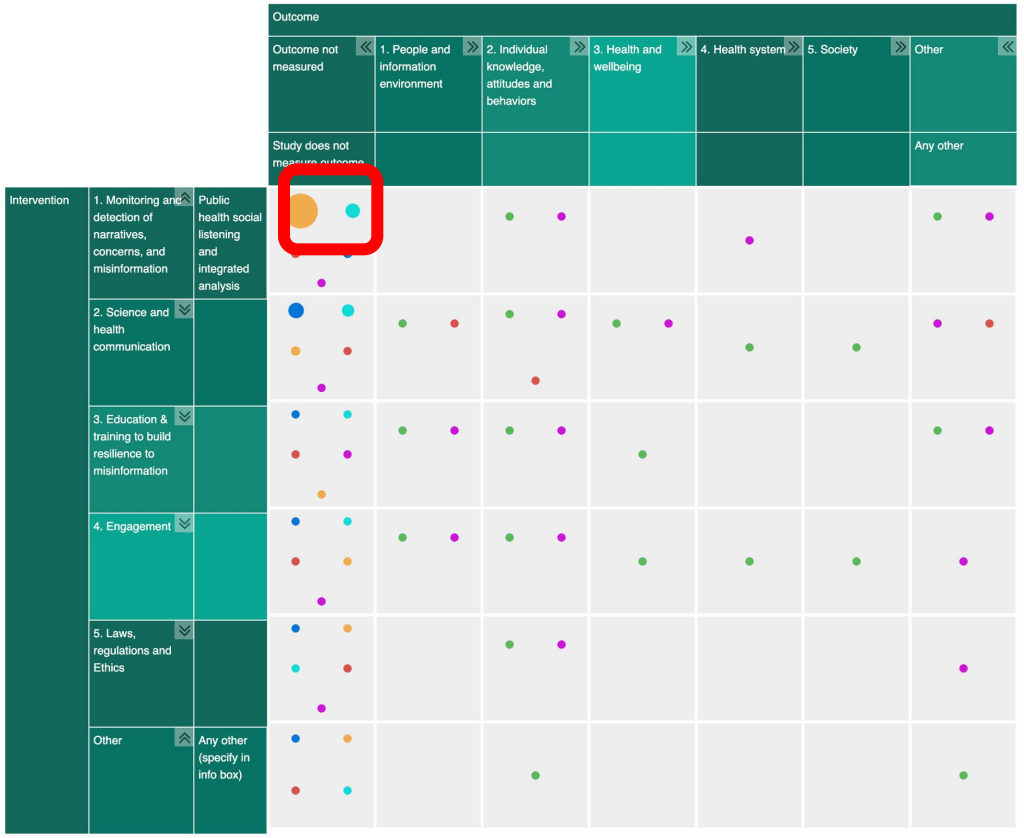


Figure 1: The evidence and gap map generated by EPPI Mapper, 2023

Artificial intelligence approaches in Infodemic Management

- Machine learning offers the unique opportunity to combat mis/disinformation using algorithms to detect mis/disinformation before they are amplified and can impact health outcomes.
- Among the 430 studies, the Model development/ testing studies were the most common (n=161), social network analysis (n=139), sentiment analysis (n=91), model comparison/ testing (n=30), predictive modelling (n=7) and Bayesian analysis studies (n=2)

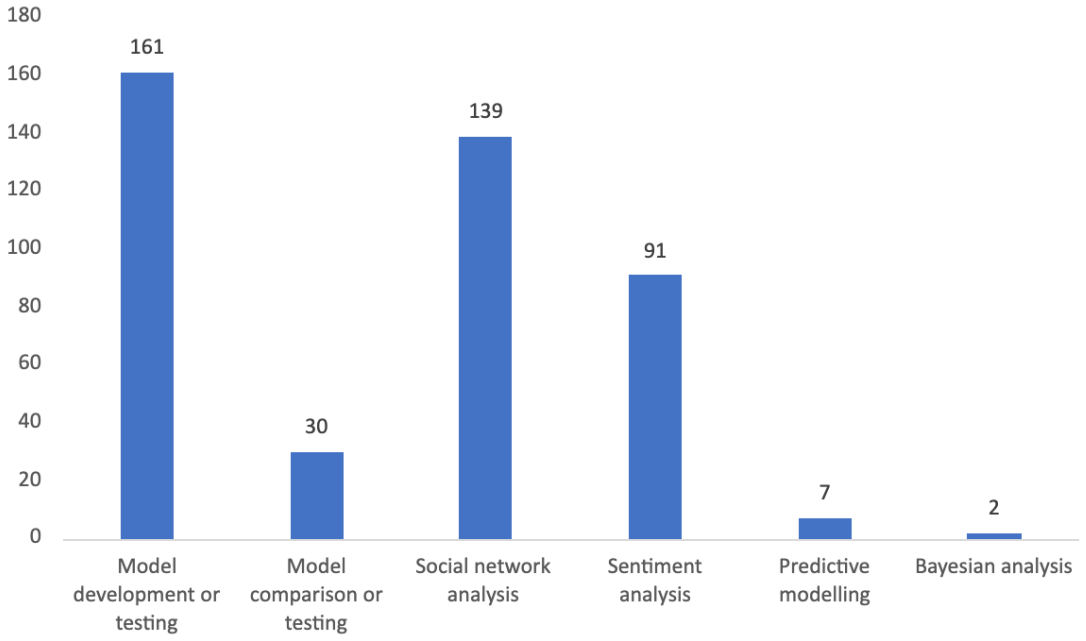


Figure 2: Bar chart showing frequencies of AI studies included in the map (Data from Jan 2020- Oct 2022)

Artificial Intelligence Studies on vaccine behaviour (vaccine acceptance or refusal or confidence)

- Sentiment analysis and text mining (of Twitter data) for vaccine behaviour were the commonest studies (among the 101 vaccine related studies) in the EGM
- AI methods, such as sentiment analysis, natural language processing, content analysis, predictive modelling and topic modelling were some of the techniques used in vaccine behaviour studies under infodemic management

Examples:

- Albaid et al. (2021) developed a framework using machine learning classification models, such as Support Vector Machine (SVM) and Naive Bayes (NB), to classify sentiment and opinions expressed on Twitter regarding COVID-19 vaccines
- In the study by Daradkeh et al.(2022), the sentiment orientation of misinformation was analyzed using a lexicon-based approach
- Wang et al. (2022) used a Latent Dirichlet Allocation (LDA) modeling analysis and a sentiment analysis to analyze the vaccine discourse themes and sentiments
- Melton et al. (2021) used sentiment analysis and Latent Dirichlet Allocation topic modeling on textual data collected from 13 Reddit communities focusing on the COVID-19 vaccine

Other studies on vaccine behaviour (vaccine acceptance or refusal or confidence)

- Studies on interventions for vaccine behavior, studies to understand infodemic spread, the relationship between fake news and vaccine behaviour, and the determinants of vaccine behaviour were also common in the EGM
- Few examples of the interventions for vaccine hesitancy and vaccine behaviour were: effect of animated/ story-based videos, infographics, social media messages to address misconceptions, communication strategies, persuasive messages for vaccine safety, and media and counselling interventions

Examples:

- Karabela (2021) investigated the relationships between perceived causes of COVID-19, attitudes towards vaccine and level of trust in information sources from the infodemic perspective in Turkey
- Lo (2022) explored the relationship between COVID-19 vaccine refusal and belief in fake news and Conspiracy Theories in Italy
- The study Amazeen (2022) investigated the effectiveness of specific and generic inoculation messages in protecting against COVID-19 vaccine misinformation among unvaccinated U.S. adults
- Domgaard (2021) identified the effects of infographics in verifying false vaccine news

1 Model development and testing

- Development and testing the performance of AI algorithms or models
- It define specific hypotheses, collect relevant data, and useful for evaluating the effectiveness, efficiency, and robustness of AI systems
- Assess the model's performance using evaluation metrics (e.g., accuracy, precision, recall, F1-score)
- Some of the AI models are:
  - Various **machine learning** and **deep learning algorithms**, including Random Forest, Support Vector Machines (SVM), and deep neural networks, were used for binary classification (true/false) of COVID-19 information
  - **Natural Language Processing** (NLP) models like **BERT** (Bidirectional Encoder Representations from Transformers)
  - Text Classification Models like **Convolutional Neural Networks (CNNs) and Recurrent Neural Networks (RNNs).**

Examples:

- In the study Agarwal et al., 2022 proposed a framework with spatial and temporal features for classification of fake news using LSTM (long short-term memory) neural networks and effectiveness of the model is described in terms of accuracy and F1 score

2 Model Comparison or testing

- Comparing different AI algorithms, model, architectures, or techniques to identify their relative strengths and weaknesses
- Evaluating and contrasting the performance of different AI algorithms or models when applied to the same problem. For example, comparing the accuracy of various machine learning classifiers for a particular classification task

Examples:

- The primary objective of the study by Alsaidi et al.,2022 was to assess the effectiveness of various machine learning algorithms in extracting fake news, with evaluation metrics including precision, recall, F1-score, and accuracy
- This paper compared four machine learning algorithms (Naive Bayes, Decision Tree, Support Vector Machines, and Logistic Regression) in detecting fake news using an annotated dataset. The results highlight Naïve Bayes as the top performer across accuracy, precision, recall, and F1 score

3 Social network analysis (SNA), content analysis and user analysis

- SNA studies the social networks of misinformation spreaders and identifies the factors that influence the spread of misinformation by finding relationships between groups in tweets/ posts
- User analysis ranks influential users by betweenness centrality and studies the behavior of users and their interaction with social media
- Content analysis studies the content of text, images, or other media and is used for identifying categories in data based on emergent coding

Examples:

1. Ahmed et al. (2020) included social network analysis, user analysis and content analysis. The study found that the largest network structures consisted of an isolates group and a broadcast group. Fake news websites were the most popular web source shared by users
2. A study by Nazar et al. (2021) analyzes the misinformation spreading during the COVID-19 pandemic by SNA/ data visualisation and content analysis of tweets

4 Sentiment analysis

- Sentiment analysis or opinion mining is a Natural Language Processing technique
- It is used to identify negative sentiment associated with certain topics or keywords, which can indicate the spread of misinformation or disinformation
- Analyzes digital text to determine if the emotional tone of the message is positive, negative, or neutral

Examples:

- A study by Biswas et al., 2022 analysed the public sentiment in tweets before and after 2020 and found that the negative tweets increased after 2020
- Chandrasekaran et al., 2022 identified that the negative sentiment was present for keywords 'postvaccination symptoms', 'side effects and 'hoax/conspiracy', and positive sentiment for keywords 'vaccination disclosure', 'vaccine efficacy', 'clinical trials and approvals', 'affordability', 'regulation', 'distribution and shortage', 'travel', 'appointment and scheduling', 'vaccination sites', 'advocacy', 'opinion leaders and endorsement', and 'gratitude toward health care workers', during the 16 weeks study

5 Predictive modelling

- Based on historical data, this model can predict the spread of mis-/disinformation to predict future outcomes
- Some of the models used: Popularity prediction, cascade prediction (Cascade prediction methods can be divided into two classes: macro-level prediction and micro-level prediction)

Examples:

- A study by Olaleye et al., 2022 described the functioning of the SCLAVOEM hyper parameter optimization approach to predictive modelling
- The study by Chen et al., 2022 employs a model to predict the spillover effect or cascading effect of misinformation and found that the identified spillover effects significantly improves the state-of-the-art Graph Neural Networks (GNN) methods in predicting the popularity of not only preventive measure messages, but also other COVID-19 messages
- A study by Scannel et al. , 2022, developed a predictive model using variables based on the Elaboration Likelihood Model, Social Judgement Theory and the Extended Parallel Process Model to determine which persuasive tactics resulted in antivaccine, provaccine and neutral sentiment

6 Bayesian Analysis studies

- A statistical method used for making probabilistic predictions and drawing inferences from data
- It is based on **Bayes' theorem**, a fundamental concept in probability theory $P(A|B)=\frac{P(B).P(B|A)}{P(A)}$
- It involves updating the probability for a hypothesis as more evidence or data becomes available
- **Naive Bayes** is a Bayesian analysis method used for simple classification algorithm based on the theorem
- It is often used in machine learning and data analysis for various tasks, including text classification, spam email detection, sentiment analysis, and more

Examples:

- The study Nistor, 2021 investigated how misinformation impacts two social learning models: sophisticated (Bayesian) and naive (DeGroot) learning (Sophisticated agents can be more prone to falling for misinformation)
- In the study Mostagir et al., 2022 used the Naive Bayes method to detect fake news on Facebook, achieving high accuracy

The role of AI in Vaccine Confidence

- AI can monitor and analyze online content to identify and flag potential sources of disinformation and misinformation on vaccines
- AI-driven fact-checking tools can automatically verify claims and statements against reliable sources
- AI can be used to develop and deliver targeted public health messages to people who are most at risk of believing and sharing misinformation.
- AI can be used to analyze large datasets of information about misinformation and disinformation to identify patterns and trends, which can be used to formation can be used to develop new tools and strategies for managing infodemics
- With AI regulations and guidance in place, it can prove to be extremely useful for building vaccine confidence and infodemic management

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