Open Access

Contemporary Research Analysis Journal

e-ISSN: 3050-5909
p-ISSN: 3050-5895

Volume 02 Issue 08 August 2025
CrossRef DOI: 10.55677/CRAJ/06-2025-Vol02I08
Page no: 504-509

Harnessing Artificial Intelligence to Revolutionize Public Health: Innovations in Prevention, Monitoring, and Policy Decision-Making

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ABSTRACT: Artificial intelligence (AI) has transformed from a sci-fi ideal to a trustworthy public health partner. This paper examines how artificial intelligence is transforming our knowledge of, approach to monitoring, and defence of public health. primarily simply acquiring data, AI tools are assisting public health practitioners in identifying notable patterns, identifying disease early warning signs, encouraging healthier lifestyle choices, and generating sophisticated proposals for policy. Five key areas are the focus of the paperearly illness surveillance, risk forecasting, wellness advice, tracking of social and environmental health impacts, and aid with evidence-based policymaking. Examples from the real world, such as how AI assisted in managing the COVID-19 crisis, assess substances, and identify populations at risk, demonstrate how these technologies enhance both regional and global responses to health issues. However, this potential also carries responsibility. The analysis addresses substantial problems like maintaining people's privacy. guaranteeing equal entry to AI-powered services and preventing bias in algorithms. It highlights that for these tools to be effective for everyone, inclusive government, openness, and public participation must be achieved. Future-focused, the use of AI to public health offers a more human-centered, responsive way for protecting health and equal treatment in a world developing more complicated than any time before.

KEYWORDS: public health, Artificial intelligence (AI), Health Promotion, Risk Prediction, Environmental and Social Health Monitoring

1. INTRODUCTION

Today's public health is at a crossroads, facing a variety of complicated and rapidly evolving issues, such as infectious disease outbreaks, the rising prevalence of chronic illnesses, climate change, and expanding health disparities. Traditional public health strategies are still essential, but in a world defined by enormous volumes of rapidly changing, diverse data, they frequently find tough to react quickly and effectively. According to Rajkomar *et al*. (2019), the appearance of artificial intelligence (AI) gives a new wave of chance that can help and advance public health projects in this data-driven era .

Health care workers can find patterns, predict dangers, and take more proactive measures with the use of AI technologies, particularly those that use machine learning (ML), natural language processing (NLP), and computer vision. According to Beam and Kohane (2018), intelligent technology (AI) simplifies decision-making and expands the reach of health services, especially to areas with limited resources, by identifying communities at higher risk, recognizing early signs of disease outbreaks, and coming up with adapted health interventions

Both the positives along with drawbacks of using AI during emergencies were brought to light by the COVID-19 pandemic. Artificial intelligence (AI) systems were extensively used in ranging from digital contact tracing and real-time outbreak tracking to vaccination logistics and resource distribution. The experience does, however, also underscore the need of data quality, ethical use, and transparency for establishing trusted and effective systems (Xu *et al*., 2020).

We examine how AI is influencing public health in diseases surveillance, behavior change support, risk prediction, and environmental monitoring in this review (Guda *et al*., 2019a). We also look into ethical and legal considerations related to these tools after reviewing worldwide case studies. In conclusion, we'll address future prospects and principles to ensure AI endorses the health of all communities with equity and ethically.

2. APPLICATIONS OF AI IN PUBLIC HEALTH

2.1 Disease Surveillance and Outbreak Prediction

Backbone of public health actions is disease surveillance to find and respond to emerging dangers before they escalate. With access to different digital health data and real-time information streams, AI is altering disease outbreak detection and forecast. It gives manual reporting and delayed feedback-heavy systems speed, precision, and adaptability (Beam & Kohane, 2018). AI-powered surveillance systems can analyse enormous datasets including hospital admissions, pharmacy records, social media movement, web searches, and images from satellites using machine learning algorithms in search of any signs of a new outbreak. NLP has enabled real-time disease mention tracking across online news websites and social media sites like Twitter, offering early insights about influenza and COVID-19 outbreaks (Xu *et al*., 2020).

Google Flu Trends was a pioneer in calculating regional flu activity from search searches. The project draw global interest in using nontraditional data sources to complement standard monitoring, nevertheless it failed due to overestimation (Lazer *et al*., 2014). From that concept, and HealthMap used AI to detect unanticipated COVID-19 illness activity before formal alerts. AI is also used in predictive modelling. AI systems may simulate disease spread based on epidemiological trends and human behavior, helping health agencies set up responses. These models guided COVID-19 lockdowns, hospital readiness, and immunization lessons (WHO, 2022).

AI enhances syndromic surveillance, which tracks symptom clusters for outbreaks. Intelligent technology may detect respiratory problems in emergency department records faster than rule-based detection. However, data quality and inclusivity are crucial to AI-driven monitoring. Lack of information may incorrect predictions and imperil vulnerable populations. Health professionals and communities must understand how these systems work and why what they achieve matter for developing public trust (Rajko mar *et al*., 2019). Instead of replacing illness monitoring, AI improves it. AI makes public health surveillance faster, responsive, and egalitarian by combining data sources and uncovering movements rapidly.

2.2 Health Promotion and Behavior Change

By giving knowledge, support, and behavior change approaches, health promotion helps people and communities make healthier choices and enhance public health. How we deliver personalized, scalable, and data-informed medical treatments has evolved with AI (Beam & Kohane, 2018).

Through mobile apps, wearables, and interactive platforms that adapt to users' habits and preferences, AI technologies support in changing behaviours. Fitness, smoking cessation, mental health, and chronic disease management use these methods. Machine learning algorithms customise recommendations based on customer behaviour and health aspects. For instance, fitness trackers change daily goals based on prior achievements, while dietary apps promote meals that adhere to health goals and hinders (Topol, 2019).

An intriguing innovation is AI chatbots or conversational agents. These virtual friends advertise and teach healthy habits. Chatbots like Woeber that provide real-time cognitive behavioural therapy, also known as CBT, have improved mental health (Fitzpatrick *et al*., 2017). Similarly, AI-driven smoking cessation programs adapt messages to user responses and progress, resulting in them more engaging and responsive. AI analyses the social aspects of health and detects at-risk people to promote community health. Social media and community feedback can be scanned by NLP systems for false information, ailments, and care impediments. Using these insights, public health efforts can be more timely, targeted, and effective (WHO, 2022). AI helps identify unhealthy habits and measure intervention progress in behavioral epidemiology. AI systems can identify behavior change patterns and offer improvements by analyzing different data sources. AI can link fitness and diet to blood glucose trends in diabetes care, driving healthier habits (Rajko mar *et al*., 2019).

Although advancements have been made, AI in health promotion must solve basic challenges to succeed. In order to give fair access and reduce disparities in health care, digital literacy gaps, privacy concerns, and algorithmic biases must be controlled. Impact also requires involvement by users, cultural relevance, and ongoing evaluation (Guda *et al*., 2019b).

Health promotion with AI is about making support more accessible, flexible, and effective. When invented well, AI can help folks manage their health and communities build permanent adjustments .

2.3 Risk Prediction and Early Detection

AI's expanding ability to anticipate health hazards and diagnose diseases early, often pre-symptomatic, is one of its biggest contributions to public health. These capacities improve patient outcomes, public health responses, and healthcare resource efficiency (Rajkomar *et al*., 2019). Artificial intelligence models analyse individual and population-level hazards using big, diversified datasets including genetic profiles, lifestyle behaviours, environmental circumstances, and social factors. These models can detect small patterns that may indicate a higher risk of diabetes, cardiovascular disease, cancer, or depression using machine learning. These systems learn from new data to improve predictions (Beam & Kohane, 2018).

Machine learning can evaluate complex clinical data including medical imaging, lab test results, and genomic information to detect early cancers. CNNs can detect sickness in X-rays and mammograms far more accurately than radiologists. AI systems can detect the beginning stages of diabetic retinopathy, enabling earlier treatment and possibly lowering vision loss (Topol, 2019). Smart

watches and mobile health apps enable real-time physiological monitoring besides clinics. These devices monitor sleep, heart rate, travel, and more. Departures from baseline might point to health issues, which AI algorithms recognize. The WHO (2022) suggests that a smartwatch could detect abnormal cardiac rhythms and prompt medical examination for atrial fibrillation . AI allows public health managers believe population risks and identify locations that need targeted interventions. Algorithms that forecast can identify vaccine-preventable disease outbreaks and chronic illness clusters, guiding education, testing, and immunization (Xu *et al*., 2020). The quality and diversity of training data influences AI prediction accuracy and fairness. Models may be skewed or incomplete if datasets neglect particular groups of people. To prevent health inequities, data collection and testing of models must be inclusive across numbers (Beam & Kohane, 2018). Ethics in risk prediction are crucial. Communicating projected hazards, controlling data, and using predictions all matter. Learning you're at high risk for a condition can cause anxiety, and insurers or employers misrepresenting such information could have catastrophic effects. AI has to boost trust and ethical public health practice through transparent processes, informed consent, and human oversight.

2.4 Environmental and Social Health Monitoring

Population health is affected by environmental and social factors. Air, water, noise, housing, socioeconomic status, and healthcare access affect illness patterns and health injustices. Environmental and social health aspects are being monitored, modelled, and responded to more accurately and rapidly using artificial intelligence (AI) (Beam & Kohane, 2018).

Sensor, satellite, remote sensing, and environmental monitoring station data are combined via AI to improve environmental health monitoring (Mutlag *et al*., 2019). These systems can detect chemicals, identify sources, and expect health effects. AI algorithms use weather, shipping, and industrial outputs to anticipate urban air pollution. Public medical providers can inform vulnerable populations and undertake measures for mitigation using such models (Rajkomar *et al*., 2019).

AI has successfully simulated the health implications of heatwaves, wildfires, floods, and droughts under climate change (Guda *et al*., 2019). Historical climate and health data can be used by machine learning algorithms for predicting how future climate-related scenarios would affect respiratory, vector-borne, and mental illness. It aids climate-resilient public health planning and early intervention (WHO, 2022).

AI is additionally changing social health monitoring, another essential public health element. AI systems can detect disparities in income, education access, food insecurity, and other social determinants by analyzing electronic health records, census data, social media, and surveys. Natural language processing (NLP) retrieves key social signals from tweets, news articles, and public comments in order to deliver real-time insights into community health standpoints, misinformation trends, and behavioral responses (Xu *et al*., 2020).

AI helps social health uncover spatial and demographic inequality in health. For instance, predictive models can map chronic diseases, hospital use, and vaccine hesitancy in disadvantaged populations. Public health officials can priorities interventions and allocate resources to the neediest. By tracking engagement and result defines across ranged populations, AI can help study community-based programs (Topol, 2019, Al Bayati *et al*., 2020).

artificially intelligent environmental and social health monitoring is difficult. Data privacy, especially location-based and social media data, is important. Without careful consideration, data collection and algorithm design biases can lead to incorrect findings. To use AI ethically and socially, transparency, community engagement, and multidisciplinary collaboration are needed.

2.5 Decision Support and Policy Modeling

From chronic disease risk to mental health, social and environmental variables impact health. Quality of air, water, noise, housing, financial status, and access to care all affect population health (Ali *et al*., 2020). Artificial intelligence (AI) is able to comprehend complex and varied data, making it a strong tool for monitoring and responding to all sorts of variables (Beam & Kohane, 2018). AI tracks air pollution, water safety, and land use using remote sensing, satellite imagery, environmental sensors, and monitoring stations. Pattern-analyzing machine learning processes can predict pollution gains.

traffic, industrial pollutants, and weather data. These findings support public health steps like notifying susceptible groups and tweaking urban planning to lower exposure (Rajkomar *et al*., 2019). Machine learning simulates the health effects of severe weather events as climate change intensifies. AI systems identify which communities are at danger for respiratory illness, infectious disease outbreaks, and psychological stress based on past data from heatwaves, wildfires, flooding, and droughts. The WHO (2022) adds that this helps public health systems plan climate-resilient interventions and allocate resources.

AI aids in analyzing societal factors of disparities in health. AI can find trends in inequality of income, food hunger, housing instability, and more by analyzing electronic health records, demographic databases, and social media. Health professionals can learn about the public's views, developing concerns, and misinformation trends from tweets, local news, and survey results using natural language processing (NLP). Xu *et al*. 2020

This intelligence allows for intervention needs. Chronic disease hotspots, low immunisation rates, and limited care the availability can be identified by predictive models. These findings help public health programs priorities outreach and support. By analyzing participation and outcome trends across populations, AI could evaluate community-based programmers' performance (Topol , 2019) .AI for environmental and social health monitoring faces significant obstacles. Analysis of location-based or personal data requires

rigorous privacy measures. Additionally, data quality and algorithmic bias remain important since unworthy or partisan inputs can perpetuate injustices.

Integrating justice into those organizations involves transparency, inclusive collaboration, and ethical oversight. When executed carefully , AI can improve environmental and social health monitoring and close public health gaps

3. CASE STUDIES AND GLOBAL EXAMPLES

Globally, AI has been used in public health to improve illness management, health promotion, and policy responses. Case studies of AI implementations worldwide show triumphs, problems, and lessons learnt.

3.1 COVID-19 Pandemic Response

AI in public health changed with the COVID-19 pandemic. For outbreak proof of identity, contact tracing, clinical decision support, and vaccine delivery, AI was quickly adopted. The Canadian operations Blue Dot utilized AI to analyze around the world flight data, media coverage, and epidemiological data to warn of the Wuhan outbreak days before government advisories (Xu *et al*., 2020). In open areas in China and other economies, AI-powered thermal imaging devices identify people with high temperatures for speedy screening. AI chatbots delivered millions of users real-time information and symptom checks, relieving healthcare systems (Beam & Kohane, 2018).

Machine-learning methods forecasted COVID-19 spread and hospital resource needs. For lockdown timing and healthcare capacity planning, US Institute for Health Metrics and Evaluation (IHME) models were widely utilized. These models were criticized for data quality issues and quickly changing epidemiological conditions, emphasizing importance for model validation and transparency (Topol, 2019).

3.2 Google Flu Trends

Google Flu Trends (GFT), released in 2008, was one of the first and most noted AI-based public health detection initiatives. Real-time influenza activity was estimated using Google search requests. GFT initially complemented CDC data, suggesting computerised methods may supplement illness tracking (Lazer *et al*., 2014). In the 2012–2013 flu season, the system overestimated flu prevalence and failed. Media coverage and other outside variables caused search behaviour changes the system was not trained for, analysts said. Concerns ended the project in 2015. The GFT scenario shows the limitations of non-traditional data streams and the worth of AI and the epidemiological field skills (Beam & Kohane, 2018).

3.3 WHO's EPI-BRAIN

AI in epidemic preparedness is seen on the WHO's Epidemic Intelligence from Open Sources (EPI-BRAIN) platform. For early outbreak detection, this method examines data from social media, news outlets, government health reports, and informal discussions on the internet. The WHO (2022) states that EPI-BRAIN turns unstructured data into useful insights using NLP and machine learning.

Because it benefits low-resource countries with poor or delayed illness surveillance, EPI-BRAIN is especially useful. The method helps WHO and member nations response faster to health emergencies by providing real-time alerts and contextual information (Xu *et al*., 2020).

3.4 AI in Chronic Disease Management

AI improves public health beyond infectious diseases. AI-driven analytics has been implemented by the NHS in the UK to detect chronic illness patients at high risk of hospital readmission, such as heart failure and diabetes. Predictive tools help clinicians to intervene early, reducing complications and relieving hospitals (Rajkomar *et al*., 2019). Digital health solutions powered by AI are essential for chronic disease self-management. Diabetes patients receive personalized diet, exercise, and medication feedback from programs. These advancements help bridge care gaps and support long-term health management in underserved or remote communities without specialists (Topol, 2019).

These examples show how AI works in various factors, from online platforms inspecting for early pandemic indicators to mobile applications managing lifelong illnesses. AI's potential to enhance reactive and preventive public health methods is brought out, as is the import of accuracy, ethics, and openness in technology progress.

4. ETHICAL AND LEGAL CHALLENGES

As AI impacts public health, legal and ethical problems arise. Technology offers great benefits, but it must be used responsibly, fairly, and with public trust (Beam & Kohane, 2018).

4.1 Data Privacy and Security

AI systems required sensitive data including medical histories, the genetic makeup of and behavior patterns. Data breach and misuse mitigation is crucial. Governance must ensure informed consent, transparent data practices, and compliance with EU and US laws which includes GDPR and HIPAA (Rajkomar *et al*., 2019).

4.2 Algorithmic Bias and Fairness

When training data lacks diversity, AI model bias might exacerbate disparities in health care. When trained on high-income data, a model may misdiagnose or miss marginalized communities. Employ inclusive datasets, audit for bias, and incorporate various parties in constructing models for complete fairness (Topol, 2019).

4.3 Transparency and Explainability

Many AI tools function as "black boxes," offering predictions without clear explanations. In healthcare, where trust and accountability are critical, this opacity is problematic. Advances in explainable AI (XAI) aim to make models more interpretable, so clinicians and public health officials can understand and validate recommendations before acting on them (Beam & Kohane, 2018).

4.4 Accountability and Liability

Who is to blame for an AI system's miscalculation or delayed outbreak? This question plagues legal systems worldwide. To hold AI developers, health care providers, and organizations accountable, liability, validation, and monitoring rules must be implemented (Rajkomar *et al*., 2019).

4.5 Informed Consent and Autonomy

AI risk prediction and behaviour modification often analyses personal data and influences health choices. Clear communication about AI's actions, data, and effects is necessary to respect individual autonomy. In passive or population-wide public health data gathering, permission is difficult (Topol, 2019).

4.6 Social and Ethical Implications

Beyond technical and legal issues, AI might impact society. These systems may exacerbate disparity by favoring those with technology and leaving others behind without care. Inclusivity, accessibility, and social justice must guide ethical design (Beam & Kohane, 2018).

Tackling these issues requires developing an enduring public health system, not just advances in technology. That involves prioritizing ethics, being transparent, and community in AI creation.

5. FUTURE DIRECTIONS AND OPPORTUNITIES

Looking ahead, AI has great potential to transform public health. Our ability to predict health needs, personalise therapies, and deliver timely, equitable care will improve as technology advances (Topol, 2019).

5.1 Integration of Multimodal Data

For improved comprehension of public health, future AI systems may mix data from electronic health records, genomics, environmental monitoring, social media, and more. This holistic approach strengthens early warning systems, tailors interventions, and priorities resource allocation (Rajkomar *et al*., 2019).

5.2 Advances in Explainable AI and Human-AI Collaboration

Public health demands trust. Explainable AI (XAI) can assist health professionals and community leaders trust AI-generated conclusions. Using AI's analytical power and human judgement and empathy, future systems will emphasize interaction between humans and machines (Beam & Kohane, 2018)**.**

5.3 AI-Driven Precision Public Health

Precision public health, including precision medicine, tailors interventions to specific groups or individuals. AI permits dynamic risk assessments and real-time health surveillance, allowing outreach inexpensive and effective in those with health issues (Topol, 2019)

5.4 Expanding Access through Digital Health Tools

As mobile health tools and wearables rises, the AI may widen public health services. These apps can track symptoms, remind patients to take medication, and provide mental health assistance in real time and scale quickly. This development is promising in low-resource or healthcare-access-challenged societies (WHO, 2022).

5.5 Addressing Ethical, Legal, and Social Implications

AI development requires ethical forethought. It provides protocols to protect privacy, combat bias, and guarantee AI benefits all groups. Building health-beneficial technology requires inclusive design procedures that incorporate marginalised people (Rajkomar *et al*., 2019).

5.6 Leveraging AI for Global Health Emergencies

Lastly, AI will grow more involved in pandemic, natural tragedy, and other situations of emergency. AI can speed up, improve decision-making by analyzing population migration, threats to the environment (Alkareemaw *et al*., 2020), and disease genomes. Medical, economic, and logistical solutions can be inspired by these systems (Xu *et al*., 2020).

AI in public health is doable. AI can make health systems more nimble, inclusive, and resilient with had infrastructure, staff training, and ethical governance.

6. CONCLUSION

AI is becoming a vital resource for boosting global public health. This review has shown how AI is improving identification of illnesses, healthy choice promotion, and policy guideline clarity and speed. AI helps us make smarter, more swift choices when it comes to outbreak prediction and community-specific health messages. kinder alternatives. AI platforms tracking global epidemics and smartphone apps supporting mental wellness show how AI could influence people's daily lives and public processes. Healthcare efficiency and empathy have been enhanced by these technology. However, advancement faces obstacles. Ensuring privacy, equity, and transparency is important. AI should serve everyone, not just the wealthy. The future will be dependent on collaboration between governments, researchers, healthcare providers, technology in order and the public. Transparent, ethical, and accountable AI systems that complement human cognition must be established. With careful development and inclusive design, AI can improve societies. In short, AI offers not just smarter solutions, but also the possibility of more humane and equitable public health. The opportunity lies not just in what AI can do, but in how we choose to use it.

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