

Review

Legal and Ethical Principles of Artificial Intelligence in Public Health: Scoping Review

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Abstract: Background: The potential of Artificial intelligent (AI) models to process and interpret large health datasets at scale could revolutionize public health and epidemiology, providing a foundation for public health. Ethics has been recognized as a priority concern in the development and deployment of AI. Because AI technology can jeopardize patient safety, privacy, and posing a new set of ethical problems that must be addressed. **Objectives:** We aim to provide a holistic view on what are the different ethical and legal principles that was addressed in the included studies regarding the use of AI in public health and what are the ethical challenges that can arise. **Methods:** Following PRISMA guideline, five bibliographic databases were used in our search: PubMed, Scopus, JSTOR, IEEE Xplore, and Google Scholar from 2015 to February 2022. Four reviewers carried out study selection and data extraction, and the data extracted was synthesized by a narrative approach. **Results:** This review included 23 unique publications out of a total of 1123 items that were initially identified. Different ethical principles regarding the uses of AI in public health and community health were identified and discussed distinctly in the current review. The common ethical and legal themes that this review focused on are equity, bias, privacy and security, safety, transparency, confidentiality, accountability, social justice, and autonomy. In addition, five ethical challenges were mentioned. **Conclusion:** Research regarding ethical and legal principles and challenges about using AI in public health specifically consider a new filed, because all previous themes are concerning the physical and patients' area where it focuses only on the clinical settings.

Keywords: ethical; legal; artificial intelligence; health; equity; public health

1. Introduction

1.1. Background

Artificial Intelligence (AI) was first introduced in 1955 and is now widely recognized as a technology that has the potential to transform healthcare and society as a whole (1). While there is no universally accepted definition of AI (2), the 1955 definition is "the science of making machines to execute activities that would require intelligence if done by people" (1), such as reasoning, learning and adaptation, sensory comprehension, and interaction (3). Increased computer power, the capacity to capture and retrieve massive amounts of data, and many key theoretical advancements prompted a renewed attention on data-driven approaches to AI in the early 2000s (4). Beyond the most apparent applications of AI, it has started to penetrate in healthcare and public health fields (5). AI-based medical devices and algorithms, according to experts, will play a significant role in the delivery of preventive, diagnostic, and therapeutic interventions (6).

While AI has received a lot of interest in the healthcare field, its impact on public health has received less attention (5). Healthcare services focuses on diagnosis and treating individual patients, whereas public health focuses on protecting and promoting the health of the entire population (7). In addition, planning and evaluation are two new

activities in public health field alongside with research and providing guidance to healthcare settings (8). The goal of public health is to attain optimal health outcomes within and across populations, particularly through the development and implementation of interventions that target preventable causes of ill health (9). The ability to accurately evaluate the burden of disease or disease risk factors in the population and, as a result, identify groups that are adversely impacted or at risk; identify best practices and measure outcomes is critical to success (10). The most common foundation for evidence-informed decision making in public health is thorough the systematic evaluation and synthesis of the available data (9). Emerging AI technologies are increasingly capable of making sense of a wide range of structured and unstructured data (2).

AI models' ability to process and interpret huge health datasets at scale can be transformative for public health and epidemiology, laying the groundwork for public health (6). The analysis of large amounts of health data from a variety of sources associated with a person, places, and time would provide more and better perspectives into the determinants of disease at both the population and individual levels, as well as help speed up public health surveillance and shape public health policies and implementation activities (6). Despite this, public health practitioners and researchers have started employing AI in a variety of tasks, including scanning for emerging outbreaks, predicting suicide using electronic health records, and detecting risk factors (5). As a result, there is a growing sense of optimism about AI's ability to improve public health; nonetheless, few AI systems have been adopted in public health institutions (11). Accelerating the use of AI can have severe concerns about AI's impact on privacy, interpretability, and bias (12).

1.2 Research Problem and Aim

Revolutions rarely occur without consequences (13). Concerns have been expressed about the unique qualities and risks associated with AI technologies (13). It has also been proposed that AI would offer a novel aspect to the healthcare environments and interactions to which it is applied, which will revolutionize them completely. With the rapid advancement of technology, calls for regulation are becoming increasingly louder. As there is no existing review that covers the common ethical and legal concepts that focuses on public health field, having this review will help identify the gaps, strengths, and limitations of the previous literature. The current review will be a scoping review focused on providing a holistic view on what are the different ethical and legal principles that was addressed in the included studies regarding the common ethical and legal challenges that was linked to AI and public health.

2. Methods

To attain the above-mentioned goal, a scoping review was conducted. PRISMA-ScR (Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews) (14) was used to conduct the scoping review. The goal is to determine the scope of existing legal and ethical principles related to AI and public health (i.e., from January 2015 till the current date).

2.1. Search Strategy

2.1.1. Search Source

The current study's search was conducted using the following bibliographic databases: Medline (PubMed), Scopus, JSTOR, IEEE Xplore, and Google Scholar. Only the first ten pages of this review were scanned from Google Scholar because hundreds of citations are usually obtained from Google Scholar and organized by relevance. Additional research relevant to the review was found in the reference lists of the listed papers (backward reference list checking). Furthermore, forward list checking was performed to ensure that the relevant research referred to by the mentioned studies were examined. The search ran from 2015 to recently (February 28th, 2022), and it covered all principles and standards relevant to the scope of this review throughout that time.

2.1.2. Search terms

In the current review, the search terms were selected based upon three elements: population (e.g., Public Health*), intervention (e.g., artificial intelligen*, machine learning, deep learning, and decision support) and outcomes (e.g., ethic*, legal*, Privacy, Autonomy, Equity, and security). Appendix A shows the search strings used for searching each electronic database.

2.2. Study eligibility criteria

A main search was conducted to find papers on the legal and ethical principles that focuses on the uses of AI in public health. The study aims to look at ethical principles that applied for the uses of AI, especially in public health rather than in the medical and clinical field. Peer-reviewed publications, reports, conference proceedings, thesis and dissertations were included in this review, but no conference abstracts, reviews, or proposals were included. There were no restrictions on study settings, population age and gender, study design, reported outcome, or publication country. The study duration was from 2015 till the current day to cover the most relevant studies.

Inclusion and exclusion criteria

Inclusion criteria

- Study undertaken in public health context.
- Study related broadly to the use of Artificial Intelligence.
- Text available in English
- Study that addresses any legal or ethical issues related to the use of artificial intelligence in public health
- Studies that were published from 2015 till 2022
- Peer-reviewed publications, reports, conference proceedings, thesis and dissertations were considered

Exclusion criteria

- Studies focused on clinical settings (imaging, diagnosis, treatment) or focuses on patient level.
- Studies undertaken in non-artificial intelligence context
- Studies that were published before 2015
- Text available in other language rather than English
- conference abstracts, reviews, or proposals were eliminated

2.3. Study selection

To screen all the articles found, a two-stage process was applied. First, four reviewers separately reviewed the title and abstract of all identified papers, removing duplicates based on the inclusion criteria given above. Rayyan, a review program, was employed to make the process go more smoothly (S3). The entire texts of potentially relevant articles were then evaluated for inclusion. MH and BS participation resolved any concerns that arise. Aside from database searches, reference lists of included studies were combed through.

2.4. Data extraction

Data was extracted from the included studies independently by four reviewers using an excel sheet. Data extracted included author names, date of publication, setting, study type, study aim, ethical principle, and legal issues (if applicable) and reported findings/author interpretations. | MW and BS participation resolved any concerns that arise.

2.5. Data Synthesis

Narrative approaches were used to synthesize the extracted data. We aim to classify the literature upon the common ethical and legal theme that was addressed in the included studies (equity, bias, security and privacy, safety, etc.). Appendix B summarized the included studies and common ethical principles that were tackled in the literatures in a table.

3. Results

3.1. Search results

In the search process of five bibliographic databases, 1123 articles were identified. After removing 149 duplicates, 974 unique titles and abstracts remained. Next, based on the review eligibility criteria, the articles were excluded at multiple screening stages: 940 citations at the title and abstract in the first screening stage and 15 citations at the full-text screening stage. Four articles were included from the forward and backward reference checking. Thus, a total of 23 articles were included in this review as shown in PRISMA chart Figure (1). Appendix C includes study ID (S1-S23) and detail of each study.

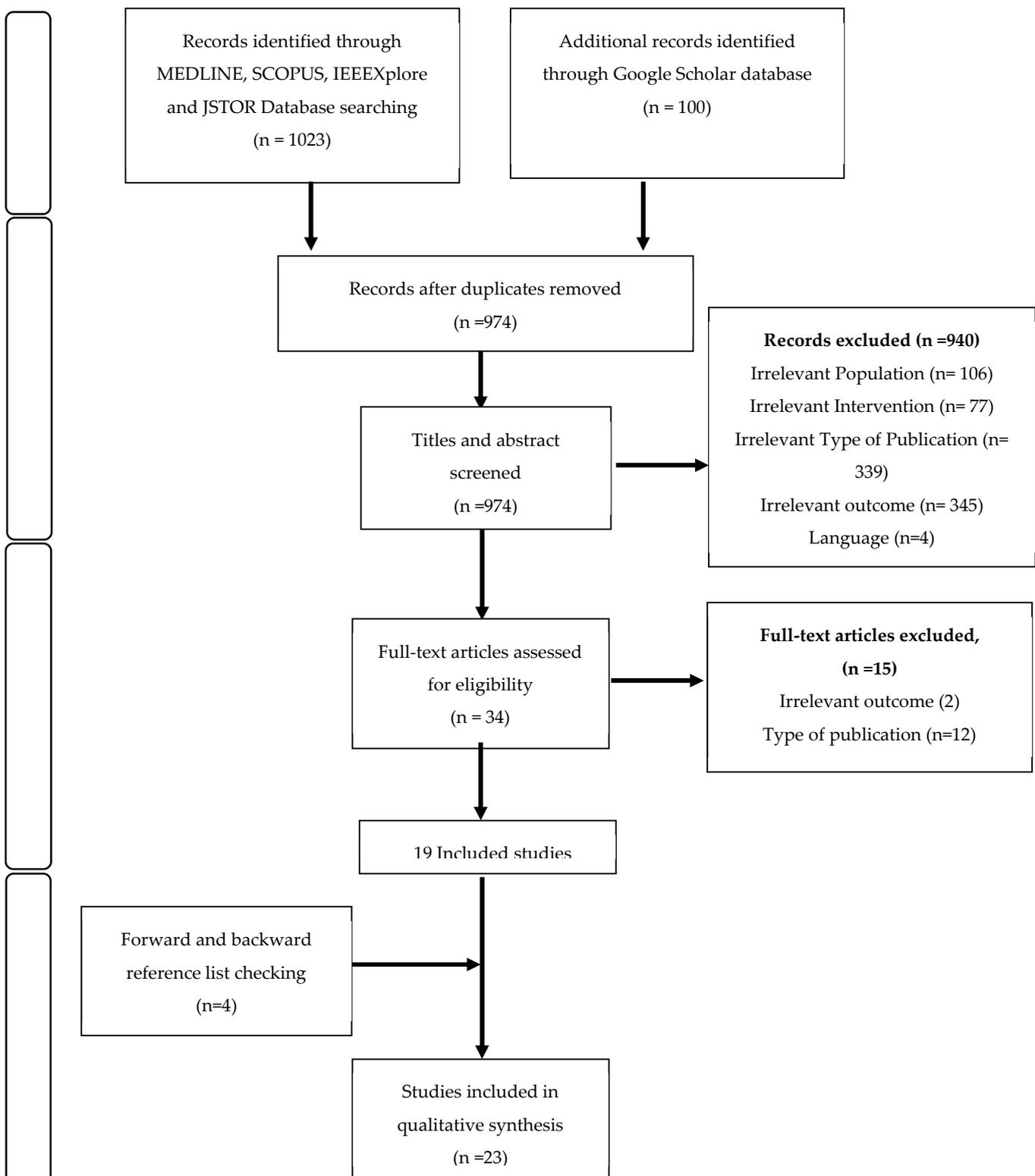


Figure 1. Flow chart of the study selection process.

3.2. Description of included studies

Table 1 presents the characteristics of the included studies. The first authors of the studies covered in this study were linked with 10 different nations, and about 60% of the studies were from the United States, followed by a smaller number from India, United

Kingdom, etc. In addition, as the inclusion criteria require the studies to be published from 2015 to 2022, most of the included studies have been published in 2020 (n=10) and 2021 (n = 8).

Table 1. Characteristics of the included studies.

Characteristics	Number of studies: 23					
Type of publication	Journal Articles: 19 (S1, S2, S3, S4, S5, S7, S8, S11, S12, S13, S14, S15, S16, S17, S18, S19, S20, S21, S22)		Report: 1 (S9)	Conference: 1 (S10)	Book Chapter: 1 (S23)	
Country	United States: 6		India: 5	UK: 3	Switzerland: 3	
	Portugal: 2	Netherland: 1	South Korea: 1	Canada: 1		
Year of publication	Australia: 1					
	2016: 1	2017: 1	2018:1	2020: 10	2021: 8	2022: 2

3.3. Description of the uses of Artificial Intelligence (AI) in Public Health

AI has many applications in public health; here, a few examples will be discussed as stated in the included literatures. Telemedicine, electronic health records, mobile health, and machine learning machine algorithms are examples of applications utilizing AI. In parallel, advances in computing power, connection, and storage capacity have accelerated health data collection, analysis, and exchange (15). Together with the increase of data gathering capabilities, these developments have resulted in the emergence of a new era of big data in healthcare, which promises to enable more precise and faster healthcare interventions (15).

Furthermore, digital technologies that employ AI to determine if users are at risk of developing or currently experiencing mental health illnesses are already accessible on the market, including public app stores and commercially available services (S1). This will help in early detection of mental illness in community members. Also, predication risk of other diseases or pandemics like covid 19, AI had a considerable contribution in that part. AI and machine learning (ML) can be used to forecast individual risk associated with covid-19 (S2). Individualized risk scores allocate medical resources to patients with covid-19 in the United States; for example, jails have tried to detect symptoms by processing convicts' phone calls (S2). New tools will be developed in the near future, such as the capacity to anticipate a person's vulnerability and detect an infection via voice. However, the employment of AI for these objectives has sparked legal problems (S2). Also, AI can provide people a daily record of their general health status by using wearable smart devices that help read basic vital signs, brain activity, and feelings (S3). This will be like a basic portable record that they can share with their family physician.

3.4. Description of the Common Ethical and Legal Themes

Different ethical principles regarding the uses of AI in public health and community health were addressed in the literature, including equity, bias, privacy and security, safety, transparency, confidentiality, accountability, social justice, and autonomy. These principles are interconnected but they were identified and discussed distinctly in the included literatures. The included studies demonstrate different ethical principles regarding AI in public health. Figure (2) shows that the included studies demonstrate nine different principles. The most common principle was security and privacy (n= 5). Followed by health equity (n=5), three studies for confidentiality, also three studies in Transparency and Autonomy. Two studies were conducted for safety, avoid unfair bias, and accountability. The least common principle used was social Justice.

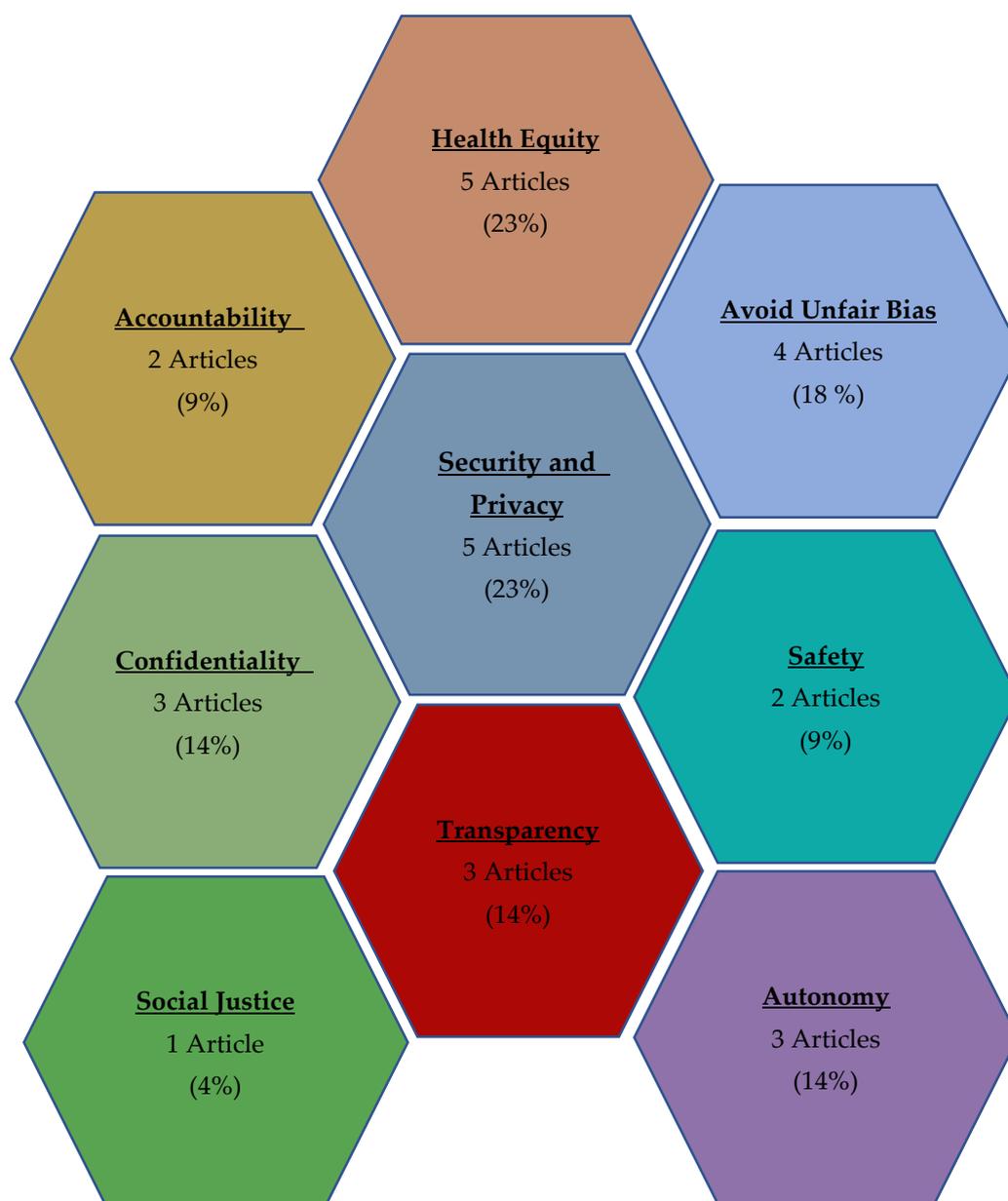


Figure 2. Map of outcome (i.e., ethical principles) measures by the number of studies in the scoping review.

3.4.1. Health Equity

Out of the 23 papers included in this review, five discussed about health equity, and each one explores this issue from a different corner. A health gap is an inequality in health that harms socially vulnerable groups (S4). Race or ethnicity has little bearing on social, economic, or health results. Problems won't go away unless they're fixed. Thus, equality and fairness are crucial in AI design, development, and use (S4). Many countries have used digital technologies to enhance medical care by designing specialized websites used to promote public health and help the community understand the risk factors for diseases and how to prevent them (S5). Not all countries have the same capabilities to improve and develop digital care or update these sites regularly; this means that not all people can equally access to health care services that are related to health promotion or even other services (S5). Promoting new technology and services to underserved populations requires ensuring that governmental policies and industry practices guarantee fair and

equal treatment (S6). The Big-Data engine's secret algorithms, data analysis systems, and profiling activities should not be allowed to discriminate (S6). Moreover, regarding non-conversational agents usage such as chatbot, low technology literacy and lack of education can eliminate the access to them where in-person or community services should be considered as an alternative to eliminate the unequal access (S7).

The urgency of the health equity concept was brought again through the COVID-19 pandemic, where the digitalization of the public health concept has become more popular (S8). The integration of digital technological advancements in public health cannot come at the expense of inadvertently increasing health disparities based on socioeconomic status. Similarly, the country-level COVID-19 response brings more attention to the unequal allocation of national and inter-provincial response resources and capacities which has resulted in significant health disparities across and within populations and countries (S8).

3.4.2. Accountability

This approach is crucial since AI affects and worries individuals and brings trust issues where AI decisions are questionable among people (S6). Two articles discussed this principle, and both citations concluded that accountability must be taken into consideration. An accountability framework approach is required in designing, developing, and implementing AI-based public health technology such as promotion, prevention, treatment plans, or the diagnosis of diseases. These decisions must be reviewed and ensure their suitability to the public and all of this puts a great responsibility on the person who is in-charge (S6). For that, all of the health personals are accountable for developing their skills in dealing with AI technology to avoid mistakes that may harm the population health significantly (S9).

3.4.3. Avoid Unfair Bias

Total of four articles discussed the bias in AI technologies used in healthcare. The three citations argue that it is complex to eliminate bias completely, but biases can arise from data, inherent biases of modelers, the model itself, or the decision-making process (S10). Thus, AI designers must remain aware of this risk and reduce possible biases at every step of product development (S5). They should consider biases while choosing ML technologies/procedures to train algorithms and datasets to program (S7). Furthermore, increasing data diversity helps decrease biases in machine learning-based risk models (S11). Simulated model cocreation can promote responsible modeling by addressing simulated effects and establishing user stories. Over and under sampling and module penalization score should be used to correct for bias in AI research (S11).

3.4.4. Security and privacy

Security and Privacy is one of the main important aspects of ethical and legal themes, 5 articles spoke about security and privacy in several ways. Security and privacy must be built into the AI development process and ensure all AI systems, data and communications that related to health are protected (S10). One of the papers focused on wearable fitness equipment that collects and analyzes user information and may help identify risk factors for many public health problems (S3). The paper also discussed that private information can be accessed illegally, which opens the door to question the correct way to deal with these devices to preserve patients' privacy and prevent any infringement that may have moral and legal consequences (S3). Users should be informed of any privacy limits imposed by the administrator (S3).

In addition, nefarious actors can compromise a study that AI models developed using open source or democratized tools (S7). Moreover, one of the articles stated that the public concerns about online privacy and loss of trust in institutions that uses digital Technologies that focuses on public awareness (S1). Finally, Indian citizens have a unique identification number linked to their demographic and biometric data through the electronic health system known as Aadhaar (S12). In 2017, the Supreme Court determined that the

Right to Privacy is fundamental in Aadhaar (S12). This decision raised arguments about the constitutionality of the Aadhaar system and if it impacts users' privacy (S12).

3.4.5. Confidentiality

Three articles were discussed confidentially related to AI technology use. In collaboration with the public health sector, clear and strong standards must be developed to ensure patient confidentiality (S9). Similarly, the WHO has created clear rules. Healthcare personnel must protect sensitive information received or kept in whatever medium, with the awareness that professional relationships may define the extent and limitations of confidentiality. Basically Patient data is required to create AI in healthcare. According to one report, India is an experiment in this area, having assigned each person a unique health identity (S13). However, the quality of this new system and its effects on individuals' information confidentiality have raised concerns in society, especially among patients who suffer from mental illnesses (S13). Moreover, geographic information systems (GIS), Global Positioning System (GPS) and related geospatial technology should be used with caution for addressing public health issues during difficult crises due to ethical considerations (S14). Geolocational data produced from actions such as tracking mobile phones without authorization of users creates fresh worries regarding the confidentiality of databases containing sensitive personal data (S14).

3.4.6. Safety

The study showed that, in order to secure the safe use of artificial intelligence technology, users must be educated on how to utilize such systems and how to interact with them in an appropriate manner (S15). Article Stated that to maintain the safe usage of artificial intelligence technologies, those who are using Digital Health systems should be educated on utilizing these systems, which would help limit the possible damage of data, providing fast and reliable clinical education, eliminating common errors and reducing costs (S16). Finally, it is critical to follow legal and ethical guidelines to ensure patient safety when working with digital health (S16).

3.4.7. Transparency

As seen in one of the included articles the biggest difficulty in terms of giving information on the development and usage of AI in public health field is a lack of transparency (S17). Article Stated that transparency in the decision-making process drives better governance by offering a better view of where and how models are used (S10). The assignment of accountability in AI, and is challenging, partly owing to the lack of transparency (S18). It Also stated That people may no longer oversee making decisions and may not understand why a poor choice has been made due to a lack of transparency. Article ensured that it is essential to understand how decisions are made using this technology (S18).

3.4.8. Social Justice

Among 23 studies, 1 (4%) study addressed Justice. This study showed that digital technologies in public health must be assessed via an anti-oppression lens, taking into account context, misuse, profit distribution, and public goods (S8). The local and global contexts in which digital technologies are produced and deployed (socio-political, economic, ecological, and historical) must be considered. also, this study reported that fair financial profit allocation among stakeholders to the creation and implementation of digital technologies, including those collecting health data, must also be considered (S8).

3.4.9. Autonomy

Two studies (4%) discussed Autonomy (S1). passive data surveillance and monitoring might result in a nontransparent kind of information asymmetry, in which the user is ignorant of which behavioral signals are employed as input features for diagnosis or

assessment (S1). This informational mismatch can have a number of consequences for autonomy. As an example, reported in this study non-clinical applications of digital psychiatry may raise autonomy difficulties that do not occur in the context of formal healthcare, most notably whether an organization has the right to interfere based on inferred knowledge (S1). The only way to get useful practical assistance for policymakers and developers in many areas is to conduct more research about how ethical principles, such as autonomy, need contextual relevance (S1). The other study states that informed consent requires complete and understandable information about a medical procedure's nature and dangers (S19). There is no consensus on whether reporting the use of an opaque medical AI algorithm should be required for informed consent. The refusal to reveal the usage of a transparent AI system may compromise patients' autonomy (S19).

In this article (S20), a paradigm for determining whether mathematical models used to estimate animal and human disease risks and control options fulfill ethical "best practices" and are thus "fit for purpose" as evidence for policymaking. This concept is based on biomedical ethical principles such as autonomy, transparency (autonomy), beneficence/non-maleficence, and fairness(S20). Ethical risks associated with model development and implementation were identified, as well as the extent to which scientists are responsible for translating and communicating model results to policymakers, so that the scientific evidence base's strengths and weaknesses (S20).

3.5. Ethical Challenges



Figure 3. Ethical challenges related to use of AI in public health. .

In terms of ethical challenges shown in figure (3) and to understand the most common ethical challenges related to AI used in public health. Five ethical issues were identified: (1) Conflicting goals: The artificial intelligence industry's economic ambitions and the UN's Sustainable Development Goals potentially hinder AI (S21). There may be various ethical justifications for deploying artificial intelligence, resulting in a non-universal standard and inequitable level of health care (S21). (2) Democratic deficits: many countries' democratic systems are weak or dysfunctional. They can't handle AI-related risks or societal impacts. As long as AI-based interactions are inferior to human interactions, increased accessibility will not alleviate the equality issue (S21). (3) Opportunity costs: replacing human intellect with AI has repercussions for citizen experiences, power structures, and political institutions (S21). (4) Risk and Uncertainty: especially in low-income nations, the promise of practical AI solutions may outweigh concerns about prospective

hazards (S21). (5) Unequal contexts: due to different contextual factors across countries, there may be other ethical bases for employing artificial intelligence, leading to a non-universal standard and an inequitable level of health care (S21). Finally, an international working group could be established by the World Health Organization to review existing ethical principles and guidelines, and to offer recommendations on how to ensure the ethical use of AI-based tools, including conversational agents (S9).

The article (S22), presents from the standpoint of public health a responsible approach to AI design, development, and application. This responsible approach should be centered on humanity's collective well-being and include ethical principles and societal ideals. Such approaches are critical since AI affects and concerns our communal health and well-being. Rather than limiting such discussions to the individual, ethical concerns with AI systems should be examined more broadly, taking into account the world's complex socio-technological reality (S22). In (S23) study, raised several ethical challenges that the use of AI in clinical practice of healthcare has huge potential to transform it for the better.

4. Discussion

This scoping review aimed to provide an overview of the legal and ethical principles that govern the use of AI in healthcare and especially in public health where it will impact public health outcomes and patient experience. Twenty-two different studies were reviewed to tackle the most common ethical and legal themes that were addressed in the included articles. Most of the studies focused on equity, bias, privacy and security, transparency autonomy, accountability, etc. where they have a significant impact on improving healthcare delivery, treatments, new therapies, adverse events will be reduced, recognizing disease patterns, early detection of outbreaks, immunization, and health promotion campaigns, eliminate disparities, and to make the healthcare system more efficient. Because everyone's entitlement to health care without any exception to gender, appearance, ethnic origin, religion, or other classifications that people use is beyond doubt. Correspondingly, the laws are focusing on equity and anti-discrimination in accessing healthcare systems as people must have an equal right to access the system and to protect their personal information. In addition, fairness should be considered at every stage of the AI lifecycle to detect any health inequality that might arise throughout the development and implementation of an AI. As a result, while considering the usage, utility, and impact of digital technologies in public health, it's important to consider whether the long- and short-term benefits and burdens are dispersed fairly among socio-demographic groups and populations. Likewise, developers and implementers must consider how and to what extent digital technologies address the underlying causes of existing health inequities and encourage upstream health equality action.

Moreover, the right of a patient to keep their information confidential must be taken seriously and be always protected. Nowadays, the wearable fitness equipment can collect and analyze the user information to identify risk factors for many public health problems, and this information can easily be accessed, and the governments should determine how these user's information must be protected. However, in this era, none of these technologies provide adequate safety to patients or consumers in their current configuration (S3). Privacy concerns are always in tension with the type and accuracy of the results obtained from a geographical health analysis. Public health data demand has increased dramatically in recent years. To address privacy concerns, de-identification techniques have been developed. SDG (Synthetic Data Generation) is a relatively new process for creating non-identifiable datasets. Health data analysts can also use it to handle small datasets and accelerate research AI models should be secure similarly to traditional software but with greater flexibility. As security must be built into the AI development process and ensure all AI systems, data, and communications are protected. The people whose lives are affected by AI systems must be safe, whether they are users or the subjects of AI-driven decisions (S10).

Accountability framework approach is needed for the design, development, and deployment of AI-based medical technology in order to recognize and solve the difficulties. Artificial intelligence is now used in the NHS as a tool to assist staff rather than as a decision-maker, which means that medical practitioners are held accountable for their decisions whether they were affected by AI technology. However, the assignment of accountability in artificial intelligence, and notably machine learning, may be challenging, partly owing to the lack of transparency. Transparency in the decision-making process drives better governance in an organization by offering a better view of where and how models are used. According to certain studies, humans may no longer have control over what decisions are made, and they may not even know or understand why a wrong decision was made, because transparency has been lost. Furthermore, Biases can arise from data, inherent biases of modelers, the model itself, or the decision-making process. AI bias is currently considered to be one of the most significant risks associated with AI and is receiving increasing attention as societal racial justice becomes more prominent. It is complex to eliminate bias completely.

When considering the ethical challenges of sharing data, it is necessary to consider a broader vantage point, meaning that digital pathologists must also enhance their commitment to choosing, equity, and trust. The European Commission's independent High-Level Expert Group on Artificial Intelligence (S21). Five areas of ethical concern were summarized in the result section. Furthermore, Luxton et al (2020) conducted those conversational agents should be used with care and consideration for the human dignity and safety of their users in mind. An international working group could be established by the World Health Organization to review existing ethical principles and guidelines on how to ensure the ethical use of artificial intelligence-based tools, including conversational agents.

4.1. Principal findings

AI in public health should be led by superior technological and ethical considerations aimed at reducing ethical risk in public health and policy interventions that are related to improving population health. In this review, the ethical and legal themes focused mostly on equity, privacy, accountability, bias, and transparency. AI's concerns exist with those raised by data collection, automation, reliance on technology in general, and those arising from the use of assistive technologies. It is critical to adopt an accountability framework approach for the design, development, and implementation of AI-based medical technology in order to better understand and address these concerns. This strategy should be based on the well-being of humanity, but also considering ethical principles and societal norms. This approach is critical since AI affects and concerns us all. We must study AI-based medical systems in the context of a multidimensional techno medical reality and dynamics within society, rather than limiting our analysis to the individual level.

4.2. Strength and limitations

4.2.1. Strengths

This review provides a preview of the common ethical principle that needs to be addressed in designing, developing, and implementing AI modules in healthcare, especially to help improve public health. In addition, this holistic view of the common themes will help the stakeholders, developers, governments, and healthcare organization take into accounts the ethical and legal principles in the process of AI design, implementing, and how it can create a positive impact on human health from every aspect while preserving their rights and autonomy.

The current review is the first that focused on the public health field, as all the previous studies and reviews focused on either specific field in the healthcare system as radiology, imaging or COVID-19 testing or in healthcare system in general. But the public health sector was always a big gap in the literature. This review is more unique and comprehensive for collecting the common ethical theme that focuses on public health in general. Therefore, this review provides a holistic view of the common principles that were

addressed in different studies such as equity, safety, privacy, bias, transparency, and accountability.

This scoping review has been done by four independent reviewers to ensure the quality and the transparency of the preformed review. As the initial title and abstract screening was done by them all, the full text screening too and the writing the report then has been divided by them. The transparency was ensured by clearly outlining the search process, study selection, and data extraction steps followed in the methods section.

4.2.2. Limitations

Although the healthcare system is a broad and comprehensive area to look at but to prevent the repetition of work (as the pre-existing work has been done regarding medical field and specific types of AI as imaging and testing AI), we restricted the work to just include public health. In addition, we used only the generic names and types of AI, which might make a difference in the current review. We acknowledge that our study has some limitations. Though this review was conducted according to the mentioned methodology five bibliographic databases were searched (MEDLINE, IEEE Xplore, SCOPUS, JSTOR and Google Scholar) to have a comprehensive view and did not cover the grey literature or preprints. Due to practical constraints, we could not search other databases (OXFORD, Cambridge Core). Correspondingly, we may have missed related studies where we did not include a variety of legal and ethical databases. Moreover, the included studies did not state the exact use of AI in public health where it addressed the themes in general bases of public health field and it did not describe the use of it in the promotion campaigns, vaccination campaigns, elderly people intervention, etc.

4.3. *Practical and research implications*

4.3.1. Practical implications

In this review, we have pointed out the different common ethical principles that are related to the use of AI in public health field, where it consists of safety, privacy and security, bias, equity, transparency, and accountability. Therefore, this review will help the AI designers and developers to know the most common and critical areas that they need to focus on to avoid any ethical challenges that might arise for the implementation of AI. Furthermore, it will help the countries in developing frameworks that address ethical principles and legal concerns to supervise the designing, developing and implementation of AI. The presence of AI ethical and legal frameworks and guidelines and ensuring the execution of it will help in achieving effective and efficient healthcare delivery, anti-discrimination societies and equal access to healthcare services.

4.3.2. Research implications

The adoption of the ethical and legal principles heavily relies on the recommendation and the reasons behind them, what are their effects, do their implementation will make a huge change in the population health and experience and are they important in the process of drafting and developing national guidelines towards the development of digital technology (AI). Digital technology deployment can make the healthcare system more efficient, adverse events will be reduced, early detection of outbreaks, promotion and prevention campaign can be easily accessed and will reach huge number of people. Furthermore, as everyone is entitling to have an equal access to healthcare services despite the differences that may occur because of the system errors, a legal and ethical principles should be taken into consideration to address all the challenges and errors that may arise.

However, this review showed the most common ethical themes that needs to be consider in all AI lifecycle from designing to the implementation phase to ensure that all people are getting the best experience and positive quality of care in all aspects. More national guidelines need to be formulated to guide the development and implementation of AI in public health field. Inconsistent themes were addressed in the included studies (e.g., privacy, security, safety, autonomy, and social justice, etc.), and there was no

recommendation on how we can develop an AI module without breaking any of these principles. In addition, the studies that were included did not mention any guidelines or principles that were tested or evaluated in real life to see the impact of their governance.

5. Conclusion

Every technology has positives, negatives, disadvantages, and advantages and that apply to AI technology too. AI is an important technology and has contributed to the progress and development of many fields, and health is one of them. There is a strong movement at all levels and countries should make sure that this technology is used correctly and must consider human rights, and that any transgression must find radical solutions for it. In public health, this technology has made a significant contribution to improving community health and discovering risk factors for some diseases. Also, provide data about community members and their health for the researcher, but the legality of obtaining this information and how to get it is a matter of wide controversy. All the ethical principles that were addressed in this review were addressed in the included studies related to public health. Different common ethical and legal themes have been identified throughout this review, such as safety, equity, transparency, accountability, privacy and security and bias. Moreover, a lot of studies has been done to examine and identify these themes, but they are entitled to a specific topic in the healthcare field as imaging, research, etc. Correspondingly, more reviews and studies are needed to provide a more in-depth understanding of these principles that related to AI in public health field to help in providing a comprehensive view to people who are in interest in designing and developing an AI module that will create an enormous impact in the public health.

Registration and protocol: Protocol is attached with this review.

Funding: There no funding located for this review

Availability of data, code and other materials: Data and code were available upon request.

Conflicts of Interest: No conflicts of financial or personal interest that may have affected this study's results were reported by the authors.

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Appendix A: Search Terms

	PubMed-MEDLINE	SCOPUS	IEEE Xplore	JSTOR	Google Scholar	
Intervention	Keywords	("artificial intelligen*" OR "machine learning" OR "deep learning" OR "decision support" OR "digital technology" OR "Chatbot")	("artificial intelligen*" OR "machine learning" OR "deep learning" OR "decision support" OR "digital technology" OR "Chatbot")	("artificial intelligen*" OR "machine learning" OR "deep learning" OR "decision support" OR "digital technology" OR "Chatbot")	("artificial intelligen*" OR "machine learning" OR "deep learning" OR "decision support" OR "digital technology" OR "Chatbot")	(((Public Health*) AND (artificial intelligence)) AND ("ethic*" OR "Privacy" OR "Autonomy" OR "Principle" OR "Equity" OR "Legal*" OR "security"))
	Keyword	("ethic*" OR "Privacy" OR "Autonomy" OR "Principle" OR "Equity" OR "Legal*" OR OR "security"))	("ethic*" OR "Privacy" OR "Autonomy" OR "Principle" OR "Equity" OR "Legal*" OR OR "security"))	("ethic*" OR "Privacy" OR "Autonomy" OR "Principle" OR "Equity" OR "Legal*" OR OR "security"))	("ethic*" OR "Privacy" OR "Autonomy" OR "Principle" OR "Equity" OR "Legal*" OR OR "security"))	
AND						
Population	MeSH	Public Health*	N/A			
	Keywords	Public Health*	Public Health	Public Health*	Public Health*	

Appendix B: Summary of the included studies:

Scopin Review: Ethical and Legal consideration of AI in Public Health								
No.	Authors	Year of publication	Country of Publication	Language	Type of Publication	Journal	Aim of the study	Ethical principles
1	Golbin & et al.	2020	United States	eng	Conference	2020 IEEE International Conference on Big Data (Big Data)	The data-driven and often black box nature of these systems does not absolve organizations from the social responsibility or increasingly commonplace regulatory requirements to confirm they work as intended and are deployed in a responsible manner, lest they run the risk of reputational damage, regulatory fines, and/or legal action. The legal community should have a good understanding of the responsible development and deployment of artificial intelligence in order to inform, translate, and advise on the legal implications of AI systems.	Bias, fairness, security, safety, privacy, transparency
2	Burr & et al.	2020	London	eng	journal	IEEE Transactions on Technology and Society	By analyzing the ethical challenges of digital psychiatry in different fields, This paper highlight key public health challenges and opportunities, and we offer concrete recommendations regarding how to safeguard and promote the welfare of the public in information societies.	Autonomy, privacy and trust
3	Amann & et al.	2020	Switzerland	eng	Journal	BMC medical informatics and decision making	The purpose of this paper is to assess the role of explainability in medical AI and to make a critical assessment of what explainability means in terms of introducing AI-driven tools into clinical practice.	autonomy, beneficence, non-maleficence, and justice.
4	Boulos & et al.	2022	Portugal	eng	journal	International journal of health geographics	This article is discussing the issue related to using geospatial data to address public health issues during challenging crises	privacy , confidentiality
5	Björk & et al.	2020	Norway	eng	journal Article	Bulletin of the World Health Organization	The aim of this paper is to use the global health sector as a case to show that the EU's guidance leaves too much room for local, contextualized discretion to foster trustworthy AI globally. Global efforts are urgently needed to protect healthcare from the potential harms caused by artificial intelligence technologies	(1) respect for human autonomy (2) prevention of harm (3) fairness (4) explicability
6	Krass & et al.	2021	United States	eng	journal Article	bmj	When a state or federal government seeks to use AI models to predict an individual's risk of covid-19, the key legal questions will ultimately turn on how effective the models are and how much they burden legal interests. We focus on two of the most salient legal concerns under US law: privacy and discrimination.	privacy, discrimination and bias
7	Montgomery & et al,	2018	United States	eng	journal Article	Journal of Information Policy	this article offers key principles and critical issues that must be considered in order to develop effective privacy , equity and consumer protections for the emerging digital health marketplace.	equity , fairness
8	World Health Organization	2021	Switzerland	Eng	Report	WHO Consultation Towards the Development of guidance on ethics and governance of artificial intelligence for health	The participants in the consultation discussed the ethical aspects of the goals and objectives of corporate and non-corporate actors in the health sector.	Privacy and confidentiality, Freedom of choice, control and autonomy, Informed consent, Bias
9	Landau, A.Y. and Ferrarello, S. and Blanchard, A. and Cato, K. and Atkins, N.	2022	United States	Eng	journal Article	Journal of the American Medical Informatics Association : JAMIA	to: (1) identify and describe key issues in development of a machine learning-based risk model and (2) provide a set of recommendations to address these ethical challenges.	equity

								and Salazar, S. and Patton, D.U. and Topaz, M.
10	Gómez-Ramírez, O & et al.	2021	Canada	eng and french	journal Article	Canadian Journal of Public Health	to stimulate purposeful reflection and to provide an orientation to the interrelated, overlapping, and co-constitutive ethical, health equity, and social justice issues that must be considered more broadly in digital public health	health equity, and social justice
11	Bhattacharya & et al.	2021	India	eng	journal Article	Indian Journal of Community Medicine	to describe the responsible approach to AI design, development, and use from a public health perspective.	Ethics guidelines for trustworthy AI
12	Bimczok & et al.	2021	Netherlands	eng	journal Article	South Eastern European Journal of Public Health	s to evaluate current legislative gaps in terms of the introduction of AI in healthcare, focusing on the domains of Data Protection, Liability & Transparency, as well as Robustness & Accuracy.	excellence and trust for using artificial intelligence
13	Dankwa-Mullan & et al.	2021	Australia	eng	journal Article	Journal of Health Care for the Poor and Underserved	framework to incorporate ethical AI principles into the development process in ways that intentionally promote racial health equity and social justice	promote racial health equity and social justice
14	Sarbadhikari, S.N. and Pradhan, K.B.	2020	India	eng	journal Article	Safety and Health at Work	enhancing the number and skill sets of the public health professionals, especially the frontline workers, it will be prudent to use the digital health technologies, including artificial intelligence, in enhancing the capacity of the healthcare professional education and delivery	safety
15	Dhingra, D. and Dabas, A.	2020	India	Eng	Global Strategy	Indian Pediatrics	There are four strategic objectives are intended to provide guidance and coordination on global digital health transformation and to strengthen synergies between initiatives and stakeholders to improve health outcomes and mitigate associated risks at all levels.	safety, security, privacy, interoperability, and the ethical use of data within and outside the health sector.
16	Thompson, C.L. and Morgan, H.M.	2020	United Kingdom	eng	journal Article	Bulletin of the World Health Organization	This paper discusses the issues highlighted within the code of conduct and the ethical challenges associated with addressing them to successfully integrate artificial intelligence within the NHS.	Transparency, accountability, public trust
17	Luxton, D.D.	2020	United states	Eng	journal Article	Bulletin of the World Health Organization	Describe the ethical implications of conversational agents in global public health	bias, privacy, risk of harm, inequitable access
18	Gopichandran & et al.	2020	India	Eng	journal Article	Bulletin of the World Health Organization	describe the ethical challenges of digital health technologies	Safety, protection, Privacy,
19	Boden, L.A. and McKendrick, I.J.	2017	United Kingdom	eng	Journal Article	Frontiers in Public Health	propose a framework to evaluate whether mathematical models that assess human and animal disease risks and control strategies meet standards consistent with ethical "good practice" and are thus "fit for purpose" as evidence in support of policy	principles of biomedical ethics: independence, transparency (autonomy), beneficence/non-maleficence, and justice.
20	Gerke, S & et al.	2020	United States	English	Book Chapter	(Artificial Intelligence in Healthcare)	This chapter will map the ethical and legal challenges posed by AI in healthcare and suggest directions for resolving them.	Informed consent, transparency, safety, fairness, bias, privacy,
21	Blasimme, A. % et al.	2016	Switzerland	eng	Journal	Journal of Public Health Policy	to explore the use and impact of digital technologies for population health and health equity gains.	Equity
22	Bondre, A. & et al.	2021	india	eng	Journal	Global Health: Science and Practice	the authors discuss the challenges in protecting mental health data privacy, guidelines to protect the personal data privacy of individuals with mental health disorders in India, and implications for digital mental health services in other low-resource settings.	Privacy, Confidentiality

Appendix C: List of the included studies

Study ID	Study Details
S1	Burr C, Morley J, Taddeo M, Floridi L. Digital Psychiatry: Risks and Opportunities for Public Health and Wellbeing. <i>IEEE Transactions on Technology and Society</i> . 2020;1(1):21-33.
S2	Krass M, Henderson P, Mello MM, Studdert DM, Ho DE. How US law will evaluate artificial intelligence for covid-19. <i>bmj</i> . 2021;372.
S3	Montgomery K, Chester J, Kopp K. Health Wearables: Ensuring Fairness, Preventing Discrimination, and Promoting Equity in an Emerging Internet-of-Things Environment. <i>Journal of Information Policy</i> . 2018;8:34-77.
S4	Dankwa-Mullan I, Scheufele EL, Matheny ME, Quintana Y, Chapman WW, Jackson G, et al. A proposed framework on integrating health equity and racial justice into the artificial intelligence development lifecycle. <i>Journal of Health Care for the Poor and Underserved</i> . 2021;32(2):300-17.
S5	Chauvin J, Perera Y, Clarke M. Digital technologies for population health and health equity gains: the perspective of public health associations. <i>J Public Health Policy</i> . 2016;37(Suppl 2):232-48.
S6	E H, D M. Policy forum. Data, privacy, and the greater good. <i>Science (New York, NY)</i> . 2015;349(6245):253-5.
S7	Luxton DD. Ethical implications of conversational agents in global public health. <i>Bulletin of the World Health Organization</i> . 2020;98(4):285-7.
S8	Gómez-Ramírez O, Iyamu I, Ablona A, Watt S, Xu AXT, Chang H-J, et al. On the imperative of thinking through the ethical, health equity, and social justice possibilities and limits of digital technologies in public health. <i>Canadian Journal of Public Health</i> . 2021;112(3):412-6.
S9	Organization WH. The importance of ethics in artificial intelligence: World Health Organization; 2021 2021. 2-3 p
S10	Golbin I, Rao AS, Hadjarian A, Krittman D. Responsible AI: A Primer for the Legal Community 2020 2020. 2121-6 p.
S11	Landau AY, Ferrarello S, Blanchard A, Cato K, Atkins N, Salazar S, et al. Developing machine learning-based models to help identify child abuse and neglect: key ethical challenges and recommended solutions. <i>Journal of the American Medical Informatics Association : JAMIA</i> . 2022;29(3):576-80.
S12	Gopichandran V, Ganeshkumar P, Dash S, Ramasamy A. Ethical challenges of digital health technologies: Aadhaar, India. <i>Bulletin of the World Health Organization</i> . 2020;98(4):277-81.
S13	Bondre A, Pathare S, Naslund JA. Protecting Mental Health Data Privacy in India: The Case of Data Linkage With Aadhaar. <i>Glob Health Sci Pract</i> . 2021;9(3):467-80.
S14	MN KB, MP K, K EE, AL C, S G, DB R. Reconciling public health common good and individual privacy: new methods and issues in geoprivacy 2022 2022-1-19. 1 p.
S15	Sarbadhikari SN, Pradhan KB. The Need for Developing Technology-Enabled, Safe, and Ethical Workforce for Healthcare Delivery. <i>Safety and Health at Work</i> . 2020;11(4):533-6.
S16	Dhingra D, Dabas A. Global Strategy on Digital Health. <i>Indian Pediatrics</i> . 2020;57(4):356-8.
S17	Bimczok SP, Godynyuk EA, Piercy J, Roppel MS, Scholz ML. How are excellence and trust for using artificial intelligence ensured? Evaluation of its current use in EU healthcare. <i>South Eastern European Journal of Public Health</i> . 2021;2021.
S18	Thompson CL, Morgan HM. Ethical barriers to artificial intelligence in the national health service, United Kingdom of Great Britain and Northern Ireland. <i>Bulletin of the World Health Organization</i> . 2020;98(4):293-5.
S19	J A, A B, E V, D F, VI M. Explainability for artificial intelligence in healthcare: a multidisciplinary perspective. <i>BMC medical informatics and decision making</i> . 2020;20(1):310.
S20	Boden LA, McKendrick JJ. Model-based policymaking: A framework to promote ethical "good practice" in mathematical modeling for public health policymaking. <i>Frontiers in Public Health</i> . 2017;5.
S21	Bærøe K, Miyata-Sturm A, Henden E. How to achieve trustworthy artificial intelligence for health. <i>Bulletin of the World Health Organization</i> . 2020;98(4):257.

S22	Bhattacharya S, Hossain MM, Juyal R, Sharma N, Pradhan KB, Singh A. Role of public health ethics for responsible use of artificial intelligence technologies. <i>Indian Journal of Community Medicine</i> . 2021;46(2):178-81.
S23	Gerke S, Minssen T, Cohen G. Ethical and legal challenges of artificial intelligence-driven healthcare. <i>Artificial intelligence in healthcare: Elsevier</i> ; 2020. p. 295-336