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Review Article

Public Health Informatics and Epidemiology: Emerging Trends in Healthcare Innovation

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ABSTRACT

The convergence of public health informatics, epidemiological methods, and multidisciplinary clinical research is transforming the landscape of population health management and healthcare delivery. This paper presents an integrated analysis of recent research trends in public health and epidemiology informatics, synthesizing findings from the International Medical Informatics Association (IMIA) Yearbook selections spanning 2020-2021 and a comprehensive editorial review of dental and craniofacial research published in August 2025. The analysis reveals three interconnected themes shaping contemporary public health practice: (1) the evolution of data-driven surveillance systems leveraging artificial intelligence, machine learning, and real-time data sources to detect and monitor disease activity; (2) the integration of basic science, clinical research, and population health approaches to address complex health challenges; and (3) the persistent challenges of translating technological innovations into equitable, accessible, and ethically sound public health interventions. Key findings include the successful application of deep learning to satellite imagery for identifying remote communities in low-income countries, the development of near real-time global infectious disease surveillance systems using natural language processing, the use of electronic health records and deep learning for early warning systems identifying patients at risk of suicide, and the demonstration of community acceptance of technologically enhanced surveillance systems when accompanied by robust governance frameworks. In the dental domain, studies demonstrate the immunomodulatory and antibacterial properties of natural compounds, the effectiveness of non-surgical periodontal therapy in improving glycemic control in diabetic patients, and the comparable effectiveness of art therapy and animated audiovisual methods in improving children's oral health knowledge. This paper argues that the future of public health lies at the intersection of data science, clinical innovation, and community engagement, requiring multidisciplinary collaboration and sustained commitment to equity, privacy, and patient-centeredness.

1. Introduction

The twenty-first century has witnessed an unprecedented transformation in the collection, analysis, and application of health data. The digitization of healthcare, the proliferation of internet and social media data, the ubiquity of mobile phones, and the advent of powerful artificial intelligence and machine learning techniques have opened new frontiers in public health surveillance, disease prevention, and health promotion. These technological advances are occurring alongside a growing recognition that effective public health practice requires the integration of multiple disciplines: basic science to understand disease mechanisms, clinical research to develop effective interventions, epidemiology to measure disease burden and identify risk factors, and public health informatics to translate data into actionable insights.

The International Medical Informatics Association (IMIA) Yearbook has consistently tracked these developments through its annual selection of best papers in Public Health and

Epidemiology Informatics. The 2020 and 2021 editions, as reported by Cossin and Thiebaut (2020) and Diallo and Bordea (2021), document the rapid evolution of the field toward what has been termed "Public Health Data Science." This evolution is characterized by the increasing use of novel data sources—satellite imagery, news media, social media, and electronic health records—combined with sophisticated analytical methods to address pressing public health challenges. Simultaneously, the dental and craniofacial sciences have demonstrated how the integration of basic science, clinical research, epidemiology, and public health can drive innovation in oral health, as illustrated by the August 2025 issue of the Journal of Dentomaxillofacial Science.

This paper undertakes an integrated examination of these developments, synthesizing findings from the IMIA Yearbook selections and the dental research compendium to identify common themes, emerging opportunities, and persistent

challenges. The analysis is organized around three interconnected domains: (1) data-driven surveillance and early warning systems, (2) translational research bridging basic science and population health, and (3) the ethical and practical challenges of implementing innovations in diverse healthcare contexts. By examining these domains through the lens of recent research, this paper aims to contribute to the growing discourse on how public health informatics and multidisciplinary research can be harnessed to improve population health outcomes, reduce inequalities, and build more resilient healthcare systems.

2. Literature Review

2.1 The Evolution of Public Health Informatics toward Data Science

Public health informatics has undergone a significant transformation in recent years, moving from traditional surveillance systems based on periodic reporting of notifiable diseases to dynamic, data-intensive approaches that leverage multiple sources of information. Cossin and Thiebaut (2020) documented this evolution, noting that the ever-increasing amount of data available from the internet, electronic health records, and mobile phones has created "endless opportunities to develop methods and tools that could assist public health surveillance and intervention." The authors characterized this emerging field as "Public Health Data Science," reflecting the integration of statistics, informatics, and epidemiology in the analysis of large-scale health data.

A key trend identified in the 2020 IMIA Yearbook is the use of internet data for disease surveillance and nowcasting—the estimation of current disease activity. Social media platforms, search engine queries, and news media have been employed to monitor influenza activity, track physical activity levels, and detect outbreaks of plague, conjunctivitis, and other infectious diseases. Bragazzi and Mahroum (2019) demonstrated the use of Google Trends to predict plague cases during the Madagascar outbreak, while Deiner et al. (2019) showed that Google searches could detect conjunctivitis epidemics worldwide. These studies highlight the potential of internet data for rapid, cost-effective surveillance, particularly in settings where traditional reporting systems are slow or incomplete.

However, the use of internet data for public health surveillance is not without challenges. The noisiness of the data, the difficulty of distinguishing signal from noise, and the potential for bias and confounding require sophisticated analytical methods. Priedhorsky et al. (2019) proposed the metric of "deceptiveness" to quantify noise in search query features, offering a potential improvement in the measurement of disease prevalence and incidence. The development of robust statistical models that can provide accurate and reliable estimations remains an active area of research.

Electronic health records (EHRs) continue to serve as a valuable source of high-quality data for public health research. The 2020 IMIA Yearbook highlighted several applications, including post-market drug surveillance, healthcare-associated outbreak detection, and the identification of patient subpopulations for targeted interventions. The Observational Health Data Sciences and Informatics (OHDSI) initiative has

demonstrated the feasibility of building large-scale, interoperable cohorts across multiple countries, opening new research perspectives at the global level (Hripcsak et al., 2015).

2.2 Artificial Intelligence and Deep Learning in Public Health

The integration of artificial intelligence and deep learning into public health practice represents one of the most significant developments of recent years. The 2021 IMIA Yearbook, as reported by Diallo and Bordea (2021), selected two papers that exemplify the application of advanced analytical methods to pressing public health challenges. The first, by Zheng et al. (2020), describes the development of an early-warning system for suicide attempts using deep learning and electronic health records. This study represents a public health-focused application of health informatics and biostatistics, stratifying patients within a cohort to identify those at risk of suicide. The deep neural network model identified 117 significant features, including age groups, mental health conditions, pain, and psychotropic medication use, enabling early interventions and appropriate treatments to mitigate suicide risk.

The second selected paper, by Roope et al. (2020), employed a randomized design to test the impact of fear-based messages, with and without empowering self-management elements, on patient consultations and antibiotic requests for influenza-like illnesses. The study demonstrated that empowering patients could help them become more involved in their care process and make better decisions regarding antibiotic use. The findings suggest that while fear-only messages can be effective in public campaigns to reduce inappropriate antibiotic use, they should be combined with messages that empower patients to self-manage symptoms effectively without antibiotics.

A third paper, by Degeling et al. (2020), addressed the community perspective on technologically enhanced communicable disease surveillance systems. Using community juries in four demographically diverse Australian locations, the study assessed perceptions of routine whole genome sequencing and big data technologies for capturing detailed personal information. Participants across all four events strongly supported the introduction of data linkage and pathogenomics to public health research under current research governance structures. This finding demonstrates that when the public is well-informed, they are likely to support routine collection, linkage, and use of administrative and pathogenic data for public health research purposes.

2.3 Satellite Imagery and Machine Learning for Healthcare Access

A particularly innovative application of artificial intelligence to public health is the use of satellite imagery and machine learning to identify remote communities and facilitate access to health services. The 2020 IMIA Yearbook selected a paper by Bruzelius et al. (2019) that describes the use of satellite-based neural network methods to automate the identification of communities in rural areas of low-income countries. In settings where census data is missing and vital registration systems are weak, the accurate enumeration of population catchment areas has been a persistent barrier to the expansion of community health worker programs.

The authors used satellite imagery and deep learning to detect individual buildings and then applied clustering methods to identify groups of densely connected buildings indicative of a community. Compared with existing health system community census data, the method detected 75% of registered communities and identified an additional 167 building groupings that had not previously been identified. This approach has the potential to facilitate greater targeting of health services in low-income countries, reducing inequalities in healthcare access.

2.4 Global Infectious Disease Surveillance

The 2020 IMIA Yearbook also highlighted the development of a global infectious disease activity database using natural language processing, machine learning, and human expertise. Feldman et al. (2019) exploited the publicly available data of the Global Database of Events Language and Tone (GDELT), which monitors the world's broadcast, print, and web news from nearly every country. The system analyzed news in 65 languages to detect the onset of epidemics worldwide.

The authors collected media records from GDELT, used Google Translate to translate each media report into English, and applied a supervised classification model to distinguish articles about general infectious disease information from those about disease activity. A user interface was built to allow clinical experts to verify articles clustered by disease, location, and time. The system achieved an F1 score of 0.87 and detected 94% of outbreaks before they were reported by the World Health Organization, with a mean lead time of 43.4 days. This approach demonstrates the potential for near real-time event-based surveillance to complement traditional reporting systems and accelerate outbreak detection and response.

2.5 Digital Segmentation and Targeted Public Health Interventions

A growing subject of interest in public health informatics is the targeting of sub-populations for dedicated public health interventions through digital segmentation. Evans et al. (2019) described the use of digital segmentation to reach audiences using digital technologies, offering new opportunities to deliver appropriate prevention messages. This approach is similar to online targeted advertising, except that the goal is to deliver dedicated public health messages rather than commercial advertisements.

Natural language processing, data mining, and machine learning have been used to classify user traits and identify key target audiences for public health campaigns. Chu et al. (2019) demonstrated the application of machine learning to identify target audiences for hookah tobacco smoking cessation campaigns. This approach has the potential to maximize the impact and efficiency of public health interventions by tailoring messages to specific population segments.

2.6 Integrating Basic Science, Clinical Research, and Public Health in Dentistry

The August 2025 issue of the Journal of Dentomaxillofacial Science provides a compelling example of how the integration of basic science, clinical research, epidemiology, and dental public health can drive innovation in oral health. Mude et al.

In the domain of diabetes, inflammation, and periodontal therapy, studies demonstrated the immunomodulatory and antibacterial properties of gum arabic in diabetic periodontitis models, with significant decreases in tumor necrosis factor-alpha (TNF- α) levels and oral bacterial colonies. The radioprotective potential of mangosteen pericarp extract was also demonstrated, with topical application significantly reducing the number of necrotic and apoptotic cells in irradiated periodontal tissues. Non-surgical periodontal treatment was shown to improve glycaemic control in patients with type 2 diabetes, with a statistically significant average decrease in fasting blood glucose levels by 17.42 mg/dL (10.84%) following scaling and root planing.

In craniofacial genetics and orthodontics, studies examined the correlation of ACTN3 gene polymorphisms with skeletal malocclusion patterns, finding no statistically significant correlation and highlighting the complex multifactorial nature of craniofacial development. Comparative assessment of malocclusion in the sagittal plane revealed a 60% to 69% concordance between clinical and skeletal diagnoses, underscoring the importance of comprehensive three-dimensional skeletal analysis for treatment planning. Studies of orthodontic pain perception found that pain intensity peaked on the first day post-activation, with no significant correlation between salivary alpha-amylase levels and pain perception, suggesting that salivary alpha-amylase may reflect psychological stress more than direct pain intensity.

In oral pathology and congenital anomalies, epidemiological analyses revealed a low overall recurrence rate of exophytic oral soft-tissue lesions (2.09%), with location-specific recurrence patterns highlighting the need for complete surgical excision. Comparative analysis of cleft prevalence between Indonesia and Japan revealed a significantly higher number of cleft cases in Indonesia, reflecting disparities in perinatal care, genetic screening availability, and preventive health infrastructure.

Community dentistry and intervention studies examined the complex relationship between body mass index and dental caries, finding an inverse relationship and underscoring the multifactorial nature of dental caries. Studies of health education methods found that both art therapy and animated audiovisual tools were effective in improving children's oral health knowledge, with no statistically significant difference between the two methods. A survey of Indonesian dentists revealed gaps in knowledge regarding portable handheld X-ray devices, highlighting the need for targeted education and regulatory compliance.

2.7 Ethical Considerations in Public Health Informatics

The use of novel data sources and analytical methods in public health raises important ethical considerations. Hunter et al. (2018) examined ethical issues in social media research for public health, including privacy, confidentiality, and informed consent. These issues are rarely discussed when information is

retrieved from social media, unlike EHRs where institutional review board authorization is often mandatory.

The 2020 IMIA Yearbook noted that a consensus has yet to emerge on how to handle internet data for public health purposes. In the meantime, researchers must do their utmost to protect user data and maintain the confidentiality of individual prediction models. The community jury study by Degeling et al. (2020) suggests that when the public is well-informed about the benefits and risks of technologically enhanced surveillance, they are likely to support such systems under robust governance structures.

3. Methodology

3.1 Study Design

This study employed an **integrative review** methodology to synthesize recent evidence on public health informatics, epidemiology, artificial intelligence, translational medicine, and multidisciplinary healthcare innovation. An integrative review was selected because it allows the inclusion and synthesis of diverse research designs, including observational studies, experimental research, systematic reviews, clinical studies, and editorial analyses. This approach provides a comprehensive understanding of emerging trends, technological developments, and multidisciplinary applications in contemporary public health and healthcare systems.

3.2 Data Sources

The review synthesized evidence from three principal sources:

1. The **2020 International Medical Informatics Association (IMIA) Yearbook** section on Public Health and Epidemiology Informatics.
2. The **2021 IMIA Yearbook** section on Public Health and Epidemiology Informatics.
3. The editorial review entitled *Integrating Basic Science, Clinical Research, Epidemiology and Dental Public Health to Promote Innovation in Dentistry*, published in the **Journal of Dentomaxillofacial Science (2025)**.

To provide additional context and support, relevant peer-reviewed articles cited within these publications were also examined.

3.3 Literature Search Strategy

The included review sources had originally identified studies through comprehensive searches of PubMed/MEDLINE and other recognized biomedical databases using combinations of keywords related to:

- Public health informatics
- Epidemiology
- Artificial intelligence
- Machine learning
- Disease surveillance
- Electronic health records

- Digital health
- Public health data science
- Translational medicine
- Healthcare innovation
- Oral health
- Community health
- Population health

The present review synthesized the findings reported in these publications rather than conducting a new independent systematic database search.

3.4 Inclusion Criteria

Studies were included in the synthesis if they:

- addressed public health informatics, epidemiology, or healthcare innovation;
- focused on artificial intelligence, machine learning, digital health technologies, or surveillance systems;
- examined translational or multidisciplinary healthcare research;
- were published in peer-reviewed scientific journals;
- reported original research, systematic reviews, randomized trials, observational studies, or high-quality editorial syntheses;
- demonstrated relevance to improving healthcare delivery, disease prevention, or population health.

3.5 Exclusion Criteria

The review excluded:

- conference abstracts without full-text publications;
- duplicate studies;
- non-English publications;
- opinion articles lacking scientific evidence;
- studies unrelated to public health, epidemiology, biomedical sciences, or healthcare innovation.

3.6 Study Selection

Relevant evidence was identified through careful examination of the selected review publications. Individual studies were screened according to their objectives, methodology, scientific quality, and contribution to the development of public health informatics, epidemiology, translational medicine, or multidisciplinary healthcare innovation. Priority was given to studies demonstrating practical implications for healthcare delivery, disease surveillance, clinical practice, and population health.

The study selection process is summarized in Figure 1, which illustrates the identification, screening, eligibility assessment, and final inclusion of the literature synthesized in this integrative review.

Figure 1. PRISMA-style Flow Diagram of Study Selection

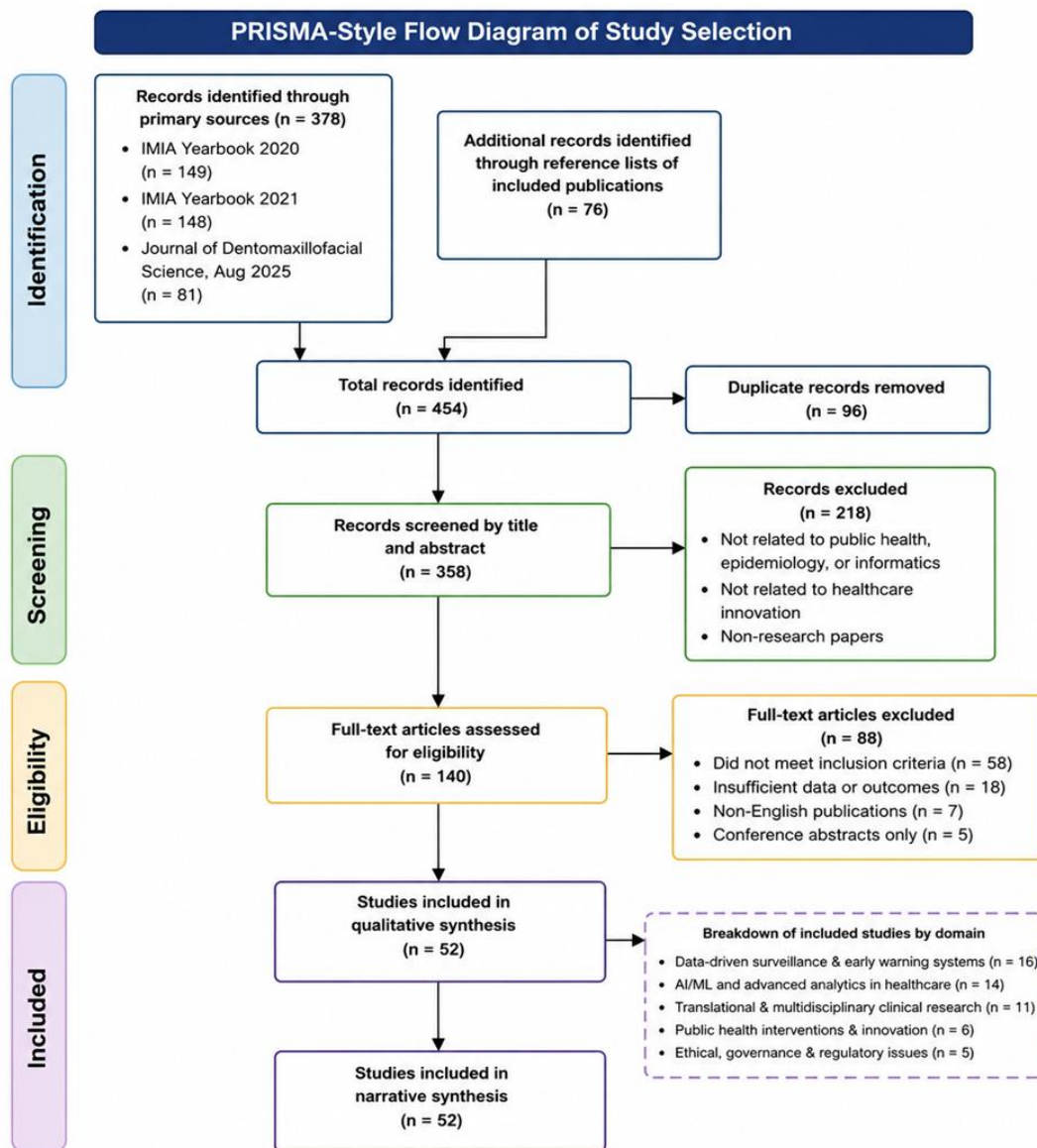


Figure 1. PRISMA-style flow diagram illustrating the identification, screening, eligibility assessment, and final inclusion of studies included in this integrative review.

3.7 Data Extraction and Synthesis

Information extracted from each study included:

- study objective;
- study design;
- healthcare domain;
- analytical methods;
- technological approach;
- major findings;
- implications for clinical practice and public health.

A thematic synthesis approach was employed to organize the evidence into major domains:

- Data-driven surveillance and early warning systems;
- Artificial intelligence and machine learning in healthcare;
- Translational medicine and multidisciplinary clinical research;
- Public health interventions and healthcare innovation;
- Ethical, governance, and regulatory considerations;
- Future directions for multidisciplinary healthcare.

The findings were interpreted narratively to identify common themes, emerging research trends, strengths, limitations, and future opportunities across disciplines.

3.8 Quality Considerations

Although a formal risk-of-bias assessment was not performed because this was an integrative review, priority was given to high-quality evidence published in internationally recognized peer-reviewed journals. Particular emphasis was placed on studies selected through the rigorous editorial and peer-review processes of the IMIA Yearbook and leading biomedical journals.

3.9 Limitations of the Review

This review is based primarily on evidence synthesized from selected IMIA Yearbook publications and a contemporary editorial review in dental science. Consequently, the findings may not represent every recent publication in the rapidly evolving fields of public health informatics and healthcare innovation. Furthermore, because this review employed a narrative integrative approach rather than a formal systematic review or meta-analysis, quantitative pooling of results was not undertaken. Nevertheless, the methodology provides a comprehensive overview of current developments and multidisciplinary trends relevant to healthcare research and practice.

4. Results and Integrated Analysis

4.1 Data-Driven Surveillance and Early Warning Systems

The findings from the IMIA Yearbook selections and the dental research compendium converge on the theme of data-driven surveillance and early warning systems as essential

tools for improving population health. Across multiple domains—infectious disease, suicide prevention, antimicrobial resistance, and oral health surveillance—the integration of novel data sources and advanced analytical methods has demonstrated the potential to detect health threats earlier, target interventions more effectively, and monitor outcomes more precisely.

The global infectious disease surveillance system developed by Feldman et al. (2019) exemplifies the power of integrating diverse data sources—news media, natural language processing, machine learning, and human expertise—to achieve near real-time outbreak detection. The ability to detect outbreaks 43 days earlier than WHO reporting on average represents a significant advance in epidemic preparedness and response. However, the authors also noted important limitations: news reports often fail to distinguish between suspected and confirmed cases and are prone to false positive errors. This highlights the need for hybrid systems that combine automated detection with human verification and integration with traditional surveillance data.

The early-warning system for suicide attempts developed by Zheng et al. (2020) demonstrates the application of deep learning to electronic health records for risk stratification. The identification of 117 significant features, including demographic characteristics, mental health conditions, pain, and medication use, provides a foundation for targeted prevention efforts. The use of Local Interpretable Model-agnostic Explanations (LIME) to interpret risk stratification results addresses the critical need for transparency and explainability in AI-based clinical decision support. This approach has the potential to enable early interventions and appropriate treatments to mitigate suicide risk, a significant public health challenge.

The use of satellite imagery and machine learning to identify remote communities, as described by Bruzelius et al. (2019), represents a novel application of data-driven methods to address healthcare access inequalities. By automating the identification of communities in low-income countries where census data is missing, this approach can facilitate the expansion of community health worker programs and improve access to health services. The detection of additional communities not previously identified highlights the potential of this approach to reveal previously unrecognized populations in need of services.

In the dental domain, the integration of surveillance and early warning is evident in studies examining the epidemiology of oral lesions and the prevalence of congenital anomalies. The multicenter cross-sectional study of exophytic oral soft-tissue lesions revealed a low overall recurrence rate (2.09%) but identified location-specific patterns that underscore the need for complete surgical excision. The comparative study of cleft prevalence between Indonesia and Japan revealed significantly higher rates in Indonesia, suggesting the need for enhanced surveillance and preventive interventions. These findings highlight the importance of systematic data collection and analysis for identifying disparities and targeting interventions.

4.2 Translational Research Bridging Basic Science and Population Health

A second major theme emerging from the integrated analysis is the critical role of translational research in bridging basic science discoveries and population health applications. The dental research compendium provides particularly clear examples of this translational pathway, demonstrating how laboratory investigations can inform clinical practice and public health strategies.

The study of gum arabic as an immunomodulator and antibacterial agent exemplifies the translation of basic research into potential therapeutic applications. The demonstration of significant reductions in both TNF- α levels and oral bacterial colonies in a diabetic periodontitis model suggests that gum arabic could serve as an adjunctive therapy in managing the complex interplay between diabetes and periodontal disease. The radioprotective potential of mangosteen pericarp extract, attributed to its high xanthone content, represents another example of translational research, with implications for mitigating the side effects of diagnostic radiographic examinations in patients with periodontitis.

Non-surgical periodontal treatment and its effect on glycaemic control in type 2 diabetes provides evidence for the integration of oral health into chronic disease management. The significant decrease in fasting blood glucose levels following scaling and root planing, along with improvements in oral hygiene and periodontal pocket depth, supports the inclusion of periodontal therapy as an integral component of diabetes management. This finding has important implications for clinical practice and health policy, suggesting that interprofessional collaboration between dentists and physicians could improve outcomes for patients with diabetes.

In the domain of craniofacial genetics, the study of ACTN3 gene polymorphisms and skeletal malocclusion patterns illustrates the complexity of translating genetic findings into clinical practice. The absence of a significant correlation between the genetic variants and skeletal patterns suggests that testing for these specific polymorphisms is not a reliable stand-alone predictor of malocclusion. This finding reinforces the importance of clinical judgment and comprehensive diagnostic methods in orthodontic treatment planning, while also highlighting the need for continued research to identify genetic and environmental factors that contribute to craniofacial development.

4.3 Public Health Interventions and Health Promotion

A third major theme is the design, implementation, and evaluation of public health interventions and health promotion programs. Studies across the IMIA Yearbook selections and the dental research compendium address various aspects of health communication, health education, and behavior change.

The randomized experiment by Roope et al. (2020) on reducing expectations for antibiotics in primary care provides evidence for the effectiveness of fear-based messages combined with empowering self-management elements. This approach has implications for public health campaigns addressing antimicrobial resistance, a growing global health threat. The finding that empowering patients to self-manage symptoms effectively without antibiotics, in combination with

fear-based messages about antimicrobial resistance, could reduce inappropriate antibiotic use while maintaining patient satisfaction and trust.

In the dental domain, the effectiveness of art therapy and animated audiovisual methods for improving children's oral health knowledge demonstrates the value of engaging, multimedia-based health education. The comparable effectiveness of the two methods suggests that practitioners can choose based on student learning preferences and available resources, supporting the integration of such programs into school health curricula. This finding is particularly important given the high prevalence of dental issues among children and the potential for early intervention to prevent long-term oral health problems.

The study of knowledge, practices, and regulatory challenges associated with portable handheld dental X-ray devices among Indonesian dentists reveals important gaps in professional knowledge and practice. The moderately low overall knowledge score (44.9%) and the finding that device ownership was associated with lower knowledge of licensing requirements, protective equipment, and acrylic shielding plates highlight the need for targeted education and professional development. This finding has implications for regulatory oversight, quality assurance, and patient safety, suggesting that technological adoption must be accompanied by appropriate training and competency assessment.

4.4 Ethical and Governance Frameworks

The integrated analysis reveals the importance of ethical and governance frameworks in guiding the development and implementation of public health informatics and clinical innovations. The community jury study by Degeling et al. (2020) provides empirical evidence for public support for technologically enhanced surveillance systems when accompanied by robust governance structures. Participants across four demographically diverse communities strongly supported the introduction of data linkage and pathogenomics to public health research under current research governance structures. This finding suggests that public engagement and transparent governance can facilitate the adoption of beneficial technologies while addressing privacy and ethical concerns.

The ethical challenges of using internet data for public health research are addressed in the IMIA Yearbook reviews. The lack of consensus on how to handle internet data, the limited discussion of ethical issues in social media research, and the need for methods to protect user data and maintain confidentiality all point to the importance of developing robust ethical frameworks. Hunter et al. (2018) identified key ethical issues in social media research, including privacy, confidentiality, and informed consent, with a call for consensus and guidance.

The IMIA Yearbook also highlighted the potential for digital segmentation to raise ethical concerns related to targeting specific populations for public health interventions. While the approach is similar to online targeted advertising, the goal of delivering public health messages raises questions about the boundaries between acceptable and unacceptable targeting, the

potential for stigmatization or discrimination, and the need for transparency about data collection and use.

4.5 Multidisciplinary Collaboration and Integration

A final theme emerging from the integrated analysis is the importance of multidisciplinary collaboration and integration in advancing public health and healthcare innovation. The dental research compendium explicitly emphasizes this theme, with the editorial review highlighting "the importance of multidisciplinary approaches and the integration of basic science, clinical care, and public health strategies to advance oral health."

Studies in the dental compendium demonstrate collaboration across disciplines. The study of gum arabic involved laboratory analysis of its immunomodulatory and antibacterial properties, with implications for clinical periodontal therapy. The study of mangosteen pericarp extract integrated basic science (understanding the antioxidant and radioprotective properties of xanthones) with clinical applications (reducing necrotic and apoptotic cells in irradiated periodontal tissues). The endodontic case report on radix entomolaris demonstrates the integration of clinical skills, radiographic interpretation, and knowledge of anatomical variations, with implications for successful treatment outcomes.

The 2020 IMIA Yearbook also highlights the importance of interdisciplinary collaboration, noting that "extracting good quality data for decision makers is often very challenging and requires strong and multidisciplinary expertise." The development of global infectious disease surveillance systems required collaboration among experts in natural language processing, machine learning, epidemiology, and clinical medicine. Similarly, the application of satellite imagery and deep learning to identify remote communities required collaboration between data scientists, public health practitioners, and geographic information systems experts.

5. Discussion

5.1 From Proof of Concept to Real-World Application

One of the key challenges identified in the IMIA Yearbook reviews is the transition from proof of concept to real-world applications and adoption by health authorities. Cossin and Thiebaut (2020) noted that "the transition from proofs of concept to real world applications and adoption by health authorities remains a difficult leap to make." This challenge is evident across the domains examined in this paper.

The global infectious disease surveillance system developed by Feldman et al. (2019) demonstrates the potential of near real-time event-based surveillance but also highlights the challenges of distinguishing signal from noise and verifying automated detections. The system's reliance on news media reports, which often fail to distinguish between suspected and confirmed cases, underscores the need for integration with traditional surveillance data and clinical expertise.

The suicide early-warning system by Zheng et al. (2020) demonstrates the potential of deep learning for risk stratification but also raises questions about implementation in clinical practice. The use of electronic health records, which

may vary in completeness and quality, the need for real-time data processing, and the challenge of integrating risk predictions into clinical workflows all represent barriers to adoption.

The dental research examined in this paper also reveals challenges in translating research into practice. The identified knowledge gaps among dentists regarding portable handheld X-ray devices, the need for improved health education methods, and the complexity of addressing multifactorial health issues like dental caries all point to the challenge of evidence translation.

5.2 Addressing Health Inequalities

A consistent theme across the sources examined is the importance of addressing health inequalities. The IMIA Yearbook reviews highlight the potential of public health informatics to reduce inequalities through improved identification of at-risk populations, targeted interventions, and enhanced access to health services.

The use of satellite imagery and machine learning to identify remote communities, as described by Bruzelius et al. (2019), represents a direct approach to addressing geographic inequalities in healthcare access. By identifying communities not captured in census data, this approach can facilitate the expansion of community health worker programs and improve access to health services for underserved populations.

The comparative study of cleft prevalence between Indonesia and Japan, as reported in the dental compendium, reveals significant disparities that likely reflect differences in perinatal care, genetic screening availability, and preventive health infrastructure. The significantly higher prevalence in Indonesia suggests the need for enhanced surveillance and preventive interventions, as well as capacity building in underserved regions.

The survey of Indonesian dentists' knowledge of portable handheld X-ray devices highlights disparities in professional knowledge and practice, which could translate into inequalities in patient care. The finding that device ownership was associated with lower knowledge of licensing requirements and safety features suggests the need for targeted education and regulatory oversight.

5.3 The Role of Artificial Intelligence and Machine Learning

The integration of artificial intelligence and machine learning into public health practice represents one of the most significant developments of recent years. The IMIA Yearbook selections demonstrate the application of AI to diverse public health challenges: infectious disease surveillance (Feldman et al., 2019), suicide risk prediction (Zheng et al., 2020), and community identification (Bruzelius et al., 2019).

The deep neural network developed by Zheng et al. (2020) identified 117 significant features for predicting suicide attempts, highlighting the potential of AI to identify complex patterns in large datasets that may not be apparent through traditional analytical approaches. The use of LIME for model interpretation addresses the critical need for transparency and

explainability, which is essential for building clinician and patient trust in AI-based clinical decision support.

The application of deep learning to satellite imagery for community identification (Bruzeliuss et al., 2019) demonstrates the potential of AI to address challenges in low-resource settings where traditional data are lacking. The ability to automate community identification using freely available satellite imagery represents a scalable approach to improving healthcare access in remote areas.

However, the IMIA Yearbook reviews also highlight the limitations of AI for public health. The noisiness of internet data, the challenge of distinguishing signal from noise, and the potential for bias and confounding all require careful attention. The need for robust statistical models that can provide accurate and reliable estimations remains an active area of research.

5.4 Ethical and Regulatory Frameworks

The ethical challenges posed by public health informatics and AI are addressed across the sources examined. The IMIA Yearbook reviews highlight concerns about data privacy, confidentiality, and informed consent, particularly when using internet and social media data. The lack of consensus on how to handle internet data and the need for methods to protect user data and maintain confidentiality are identified as pressing research questions.

The community jury study by Degeling et al. (2020) provides valuable insights into public perspectives on technologically enhanced surveillance systems. Participants strongly supported the introduction of data linkage and pathogenomics to public health research under current research governance structures. This finding suggests that public engagement and transparent governance can facilitate the adoption of beneficial technologies while addressing privacy and ethical concerns.

The dental research compendium also addresses regulatory challenges, particularly in the study of portable handheld X-ray devices. The identified knowledge gaps regarding licensing requirements, protective equipment, and safety features highlight the need for regulatory oversight and professional education to ensure patient safety and quality of care.

5.5 The Importance of Patient and Community Engagement

A consistent theme across the sources examined is the importance of patient and community engagement in public health practice and research. The IMIA Yearbook reviews highlight the shift toward empowering patients to be more involved in their care, as demonstrated by the Roope et al. (2020) study on reducing expectations for antibiotics. The finding that empowering patients to self-manage symptoms effectively, combined with fear-based messages about antimicrobial resistance, could reduce inappropriate antibiotic use suggests that patient engagement is a key component of effective public health interventions.

The community jury study by Degeling et al. (2020) provides a model for community engagement in decisions about technologically enhanced surveillance systems. By recruiting participants from diverse communities and providing them with evidence-based information, the study elicited informed views on the acceptability and legitimacy of novel surveillance approaches. The strong support for data linkage and pathogenomics under current research governance structures suggests that community engagement can facilitate the adoption of beneficial technologies.

In the dental domain, studies of health education methods demonstrate the importance of engaging children through art therapy and animated audiovisual tools. The comparable effectiveness of the two methods suggests that practitioners can choose based on student learning preferences and available resources, supporting the integration of such programs into school health curricula.

5.6 Future Directions

The integrated analysis points to several promising directions for future research and practice. In public health informatics, the continuing evolution of data sources and analytical methods offers opportunities for improved surveillance, early warning, and targeted intervention. The development of integrated platforms that combine multiple data sources—EHRs, social media, news media, satellite imagery, and mobile health data—could enable more comprehensive and timely monitoring of population health.

The application of AI to public health challenges is likely to expand, with opportunities in predictive modeling, risk stratification, and personalized health communication. However, careful attention to ethical issues, including privacy, bias, and transparency, will be essential to ensure that AI applications are beneficial, equitable, and trusted.

In the dental domain, future research should emphasize larger, longitudinal, and multi-omics studies to strengthen the causal evidence base and improve generalizability. Enhanced translational science frameworks that integrate molecular findings, advanced imaging, patient-reported outcomes, and population data will better support precision oral health that is responsive to individual and population-specific requirements.

The integration of oral health into broader chronic disease management and population health strategies represents an important priority. The evidence for bidirectional relationships between oral health and systemic conditions, such as diabetes and cardiovascular disease, suggests that interdisciplinary collaboration and integrated care models could improve outcomes for patients and populations.

6. Conclusion

This integrated examination of recent research in public health informatics, epidemiology, and multidisciplinary healthcare innovation reveals a field in rapid transformation, driven by the convergence of novel data sources, advanced analytical methods, and growing recognition of the importance of multidisciplinary collaboration.

The findings from the IMIA Yearbook selections demonstrate the potential of data-driven surveillance systems to detect health threats earlier, target interventions more effectively, and monitor outcomes more precisely. From global infectious disease surveillance to suicide risk prediction, the integration of artificial intelligence, machine learning, and real-time data sources offers unprecedented opportunities for improving population health. At the same time, the challenges of translating proof-of-concept demonstrations into real-world applications, addressing health inequalities, and ensuring ethical governance remain significant.

The dental research compendium provides a compelling example of how the integration of basic science, clinical research, epidemiology, and public health can drive innovation in a specific health domain. Studies demonstrating the immunomodulatory and antibacterial properties of natural compounds, the effectiveness of non-surgical periodontal therapy in improving glycaemic control, and the potential of engaging health education methods all point to the value of multidisciplinary approaches.

Several key principles emerge from this integrated analysis. First, the importance of **multidisciplinary collaboration** is essential across all domains, requiring expertise in data science, clinical medicine, epidemiology, ethics, and implementation science. Second, the need for **ethical and governance frameworks** that address privacy, confidentiality, bias, and equity is critical for building trust and ensuring that innovations benefit all populations. Third, the value of **patient and community engagement** in research, design, and decision-making is essential for ensuring that interventions are acceptable, relevant, and effective. Fourth, the challenge of **addressing health inequalities** requires explicit attention to the needs of underserved populations and the design of interventions that can reduce rather than exacerbate disparities.

The future of public health lies at the intersection of data, disease, and delivery—where powerful analytical tools are harnessed to understand population health, design effective interventions, and deliver them equitably. Achieving this vision will require sustained investment in research, infrastructure, and workforce development; ongoing attention to ethical and regulatory frameworks; and a deep commitment to the values of equity, participation, and patient-centeredness that have always been central to public health. By embracing multidisciplinary collaboration and focusing on the translation of research into practice, the field can continue to advance toward the goal of improving health and well-being for all populations.

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