Digital Transformation in Environmental Health Data Management: A Contemporary Need

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Abstract: In this age, Environmental Health needs to digitally transform its data management system to embrace the digital paradigm shift in society and leverage all presented opportunities. Digital transformation has changed how many organisations operate and deliver value to their customers by harnessing the power of data to gain valuable insights and improve operational efficiencies. Data in Environmental Health is key to enabling practitioners and decision-makers to implement data-driven measures to protect people's health and the environment. This study aimed to assess digital transformation and the use of data in the provision of Environmental Health Services in 11 municipalities in the KwaZulu-Natal Province, South Africa. An explanatory sequential mixed-methods study design was used, starting with a quantitative phase that entailed an online survey, whereby 105 environmental health practitioners participated. The qualitative phase followed, where 10 environmental health managers were interviewed. For data analysis, IBM SPSS Statistics 29.0 was used for quantitative data, and the ATLAS.ti software version 24.0.0.29576 was used for qualitative data. Data from both phases were integrated to derive joint results. The results indicate that most environmental health practitioners (66.7%) were not satisfied at all with the digitalisation of Environmental Health data management in their municipalities. Data management practices were found to be mainly paper-based and ineffective. As a result, administrative work overburden was reported by 90.5% of the environmental health practitioners and negatively affected their use of data for decision-making (p=0.038). These results indicate a need for the review and digitalisation of Environmental Health data management in South Africa, to streamline operational processes, and leverage available opportunities. The adoption of digital technologies and improvement of data use can enable evidence-based decision-making, lead to more proactive and effective delivery of Environmental Health Services and yield better health outcomes in the community.

Keywords: Data use, digital transformation, Environmental Health, Environmental Health data management, Public Health

Introduction

In year 2020 the COVID-19 pandemic caused massive disruptions in societies and health systems globally, resulting to the adoption of digital technologies and the increased use of data in the methods of routine health services delivery and the deployment of public health interventions (Ibrahim, 2020). As much as there were technological and digital advancements as well as data-driven decision-making in the health sector before, the COVID-19 pandemic served as a catalyst for change, accelerating digitalisation as a tool to support public health and provide swift solutions to many government agencies (Jazieh & Kozlakidis, 2020). According to Paulin, Anthopoulos and Reddick (2017), digitalisation is the adoption and usage of digital or computerised technology for heavy automation and transformation of various operational processes. Digitalisation enhances operational efficiencies and provides an opportunity of harnessing the power of data to gain valuable insights that should drive decision-making (Sinhasane, 2022). As a result, digitisation in the health sector must be embraced to leverage all presented opportunities. As part of many benefits, digitalisation in the health sector facilitates simultaneous online

access to systems by practitioners, service providers and community members as clients, anywhere, at any time, thereby accelerating the collection and delivery of information and services (Stewart & Newman, 2018).

As health requirements change, public expectations rise, ambitious new health goals get set, and the standard for what health systems must offer to yield higher social value and better health outcomes rises (Kruk et al., 2018). To respond to changing health needs, Cline and Luiz (2013) mentioned that routine health data management also needs to be relevant to current and emerging issues, as well as to technological advancements in society. The World Health Organization's (WHO) Global Strategy on Digital Health 2020 - 2025 says that a digitalised health sector should be an integral part of health priorities and benefit people in a way that is ethical, safe, secure, reliable, equitable and sustainable (WHO, 2021). This strategy further mentions that digitalised health services enable countries to use health data to promote the health and well-being of their citizens, through preventing, detecting and responding to public health issues and achieve health-related Sustainable Development Goals. Therefore, digital transformation in the health sector, including in Environmental Health Services (EHS), is very important as it enables data capturing, data exchange and storage (WHO, 2020). This transformation also allows the sharing of information across the health ecosystem and beyond, enhancing health outcomes and creating more evidence-based knowledge, skills and competence for professionals to support the health system (Kowatsch et al., 2019).

In the provision of EHS, data is very important for utilisation to ensure that people live, play and work in safe and healthy environments. EHS are governmental services mainly provided at a municipal level to identify, evaluate, prevent and control environmental factors from negatively affecting human health (Ordóñez, 2024). In South Africa, the major functions of EHS include food safety and hygiene, water quality monitoring, waste management, health surveillance of premises, surveillance and prevention of communicable diseases, vector control, environmental pollution control, management of human remains and chemical safety (Poswa, 2017). These functions are carried out by environmental health practitioners (EHP), employed by municipalities to administer and enforce environmental health related legislation and ensure the implementation of control measures to address public health risks and reduce the environmental burden of disease (Poswa, 2017; Agenbag, 2015). Therefore, in the quest for a conducive environment to human health, data should be used to indicate the extent of environmental health risks in cities, districts, and neighbourhoods to inform required interventions (Wright & Street, 2016). This is based on that data in Environmental Health is key to enable decision-makers and health practitioners to be able to implement data-driven measures to protect people's health through the prevention and management of health risks (Joas et al., 2018). A study by Mbazima, Mbonane and Masekameni (2021) found that the delivery of EHS in South Africa lacked a data science approach, for quick data-driven interventions. Whereas digital technologies in this current age can streamline Environmental Health data management and promote effective data use to enable quick response to ever-increasing public health issues in the community (Ramroop, 2021). In the efforts towards improved, effective and efficient delivery of EHS in South Africa. This study was conducted to assess digital transformation and the use of data in the municipalities that provide EHS.

Materials and Methods

Study Design

An explanatory sequential mixed methods study design was employed in this study. Whereby a quantitative phase was firstly enrolled through an online survey that targeted EHPs. A qualitative phase followed to collect qualitative data from environmental health managers through interviews, to probe further from the quantitative findings of the survey. The use of this study design allowed the integration of the findings from both quantitative and qualitative phases to provide a complete and in-depth understanding of the phenomenon. These two phases were sequentially conducted with the broader purpose of investigating digital transformation in Environmental Health data management and data use in the municipalities that provide EHS. Figure 1 displays the implementation of the explanatory sequential mixed methods design in this study.

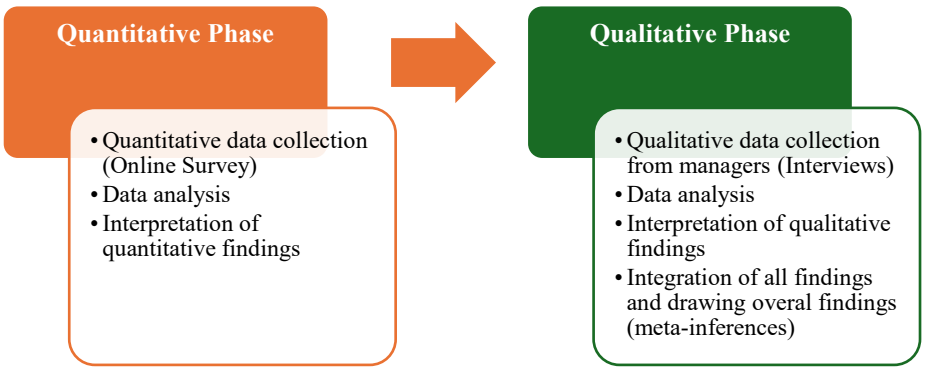

Figure 1: Implementation of the explanatory sequential mixed methods design in this study

Study Setting

This study was conducted in the province of KwaZulu-Natal in South Africa. The KwaZulu-Natal province is one of the nine administrative divisions of South Africa, and it is the second most populated province in the country with a population of about 12.4 million people (Statistics South Africa, 2023). This province, like the rest of South Africa is faced with climate change public health effects, outbreaks, unplanned urbanisation, rapid growth of informal settlements, non- compliance of businesses, air quality issues in industrialised areas, water quality issues and poor waste management (Bouchard et al., 2023; Khabo-Mmekoa & Momba, 2019; South African Local Government Association, 2018; Ntshangase, Ghuman & Haffejee, 2022). All these challenges, requires effective data use for quick interventions and strengthened EHS (Agenbag, Human & Schutte, 2022). When it comes to the provision of EHS in the KwaZulu-Natal province, 13 municipalities (1 metropolitan municipality, 10 district municipalities and 2 local municipalities) were providing these services (South African Local Government Association, 2018). Therefore, within the KwaZulu-Natal province, the study initially targeted all 13 municipalities that provided EHS in the province. However, due to that two municipalities didn't grant permission for this study to be conducted on their premises, the focus of the study shrank to 11 municipalities.

Study Population

Within the municipalities that provide EHS in KwaZulu-Natal, this study targeted two population groups of Environmental Health personnel that were employed and key in the provision of EHS. Those were 228 EHPs and 42 environmental health managers who were practising under the 11 municipalities and registered with the Health Professions Council of South Africa under the Environmental Health Board as independent EHPs, as informed by the 2023/2024 database from the South African Local Government Association (2023). For distinction in this study, EHPs at a management level are referred to as environmental health managers and those at an operational level as EHPs. The 2023/2024 database for EHPs and environmental health managers in the 11 municipalities is shown in Table 1. Due to the confidentiality nature of this study, the names of the municipalities were replaced with different allocated identification codes.

Table 1: Population of EHPs and environmental health managers in the studied municipalities

Municipalities in codes	Total number of EHPs per municipality	Total number of environmental health managers
#001	5	2
#002	10	1
#003	14	1
#004	12	1
#005	5	1
#006	9	1
#007	8	3
#008	139	19
#009	4	4
#010	6	4
#011	16	5
Total number	228	42

Quantitative Phase

The quantitative phase of this study used quantitative methods, as it intended to get mainly numerical data to be used towards understanding the phenomenon and developing numerical findings.

Sampling

In this phase, a non-probability sampling approach was adopted to draw a study sample from the population of 228 EHPs. This approach was adopted since the representativeness of the sample could not be determined per municipality, and it would be difficult for the researcher to ensure that each participant had an equal probability of being included in the sample, due to the vastness of the study area and population. Therefore, a convenience sampling method was used to include all the individuals who met the inclusion criteria, and their participation relied on receiving the recruitment email, as well as on their availability and interest to participate. The inclusion criteria required EHPs that were registered with the Health Professions Council of South Africa as independent practitioners and employed at an operational level in the 11 municipalities that agreed to be part of this study. EHPs were recruited via email to participate. The emails were circulated to targeted EHPs with an information letter and a web-based link to the online consent form for agreeing or disagreeing to participate and to give access to the online questionnaire to those who agreed to participate. Email addresses of EHPs were sought from the management of the municipalities. From the population of 228 EHPs, a sample of 105 EHPs participated, yielding a response rate of 46%. This sample was reached after all the 228 EHPs were requested via email to form part of the study, and those who were available and interested participated. This was a strategy to counter the low response rate that was anticipated. In online surveys which target health professionals, the response turnout can be low due to their unavailability for various reasons (Cho, Johnson & Vangeest, 2013; Weaver, Beebe & Rockwood, 2019; Ellis et al., 2022). Due to the structure of the questionnaire, as well as its anonymity nature, the researcher could not provide a breakdown of the response rate per municipality.

Data collection

To collect data from EHPs, a structured self-administered questionnaire that was converted to an online form via Google Forms was used. This questionnaire was designed to get information on the prospects of digitalisation in Environmental Health data management and on the use of data for decision-making. As the questionnaire was converted to an online form, it was shared quickly via email by the researcher and enabled participants to answer questions and quickly submit their responses in real-time, after online completion. Quantitative data collection was conducted from January 2024 to the end of February 2024.

Data analysis

The responses that were received from the EHPs were imported into IBM SPSS Statistics 29.0 for data analysis. As a result, descriptive and inferential statistics were used to analyse the data. In descriptive statistics, frequency tables were used for single-response questions, custom tables were used for multiple-response questions and Likert-type response questions. Inferential statistical analysis was conducted to quantify associations between identified variables of interest. As a result, non-parametric tests (Spearman's Rho) for correlations were also conducted to measure the existence of any relationships between the selected ordinal variables, as they were not normally distributed. The results of the quantitative phase are discussed with the results of the qualitative phase under the results section.

Qualitative Phase

The qualitative phase of this study was conducted to connect to the findings of the first phase and source further information on the phenomenon, to promote completeness of the study in terms of its purpose.

Sampling

A non-probability sampling approach was adopted to purposively select participants in this qualitative phase of the study. Therefore, a purposive sampling method was used by the researcher to select managers who were interviewed from the municipalities that formed part of the study. These managers were selected to obtain detailed information on the subject matter, as part of following up from the quantitative phase. From a population of 42 managers in 11 municipalities, a sample of 16 managers was purposively selected to be recruited for interviews. These managers were selected because of their occupational responsibilities (monitoring and evaluation, quality assurance,

informatics, administration of the information system, and general environmental health management) and experience with the subject of this study. Managers who were selected to be requested to participate were those who were employed in the provision of EHS and registered with the Health Professions Council of South Africa as independent practitioners under the Environmental Health Board. From the sample of 16 managers that were recruited, 10 responded positively and agreed to be interviewed, yielding a response rate of 62.5%. Table 2 shows the number of managers who were requested to participate in the 11 municipalities and those who agreed to participate.

Table 2: Participation of Environmental Health managers in the interviews

Municipalities in codes	Number of managers requested to participate	Number of managers who participated
#001	2	1
#002	1	0
#003	1	1
#004	1	0
#005	1	0
#006	1	0
#007	1	1
#008	4	4
#009	2	1
#010	1	1
#011	2	1
Total	16	10

Data collection

Data collection for the qualitative phase was conducted from February 2024 to April 2024, using a semi-structured interview guide. The interview guide was made up of mainly open-ended questions, to source in-depth information from environmental health managers on digitalisation in Environmental Health data management and on the use of data for decision-making. Data in this phase was collected from 10 managers who agreed to participate, and with this number of participants and the information that they provided, data saturation was reached. The researcher conducted all the interviews and manually transcribed the data. One-on-one interviews were conducted virtually and physically in private settings that accommodated the participants. All the transcribed data was typed and stored as transcripts in the researcher's computer, to await data analysis.

Data analysis

Qualitative data analysis was conducted by using ATLAS.ti version 24.0.0.29576, whereby deductive and inductive thematic analysis methods were applied. The transcripts were imported into ATLAS.ti, and then the researcher read them to understand and note initial impressions. Through following the deductive thematic analysis method, the qualitative data was then segmented into quotations and then deductively coded according to predetermined themes to allow further analysis. These coded quotations were then read by the researcher to analyse, interpret them and generate findings. To further analyse the imported data, inductive thematic analysis was conducted to observe patterns from the uncoded data in the transcripts to determine new emerging themes of interest, to generate more results. As a result, new important and meaningful data that was not related to the predetermined themes were identified, segmented, and inductively coded into one theme of interest. This data segmentation was conducted until code saturation was reached, as no new codes were emerging from the dataset. The data within this theme was used to enable further data analysis and interpretation to provide more inputs to the results of the qualitative phase and the findings of this study.

Data Integration

The results from both phases were integrated to conduct triangulation to develop a comprehensive understanding of the phenomena and draw findings. This integration was important in this study, as it allowed the results from the qualitative data to provide further explanation of the results obtained from the quantitative data. The integration of data took place in this study at an interpretation and reporting level after data analysis was conducted in both the quantitative phase, as well as in the qualitative phase. The integrated results (meta-inferences) are presented in the results section.

Ethical Considerations

Approval for this study was obtained from the Faculty of Health Science's Research Ethics Committee (REC-2469-2023) and the Higher Degrees Committee (HDC-01-94-2023) at the University of Johannesburg. The permission to access the municipalities was received from the South African Local Government Association, as well as the management of the municipalities that participated. Informed consent was obtained from all the participants for their voluntary participation. Participants were informed that their right to withdraw from the study at any time was guaranteed. Participants were treated with respect and dignity. No harm to participants took place. Anonymity, privacy and confidentiality were ensured.

Results

Digital Transformation in Environmental Health Data Management

Environmental Health data management was found to be mainly paper-based and lacking technological advancements in the studied municipalities. As it was found that EHPs in their routine work generate data and record them in checklists (inspection and investigation tools) (n=87; 82.8%), reports (n=77; 73.3%), daily/weekly activity books (n=67; 63.8%), notebooks and diaries (n=53; 50.4%), before being captured into paper-based weekly and monthly input data forms for further collation and recording into Web-DHIS. To store the records of work conducted, managers and most EHPs (n=101; 96.1%) indicated that they use manual paper-based systems (e.g. cabinets, files, registers, books etc.) for hard copies, and computers (n=71; 67.6%) for soft copies. The use of digital systems, like cloud storage (n=26; 24.7%) and software-based storage (n=9; 8.9%) was very low, which kept the data in file cabinets vulnerable to tempering, as well as being lost or destroyed. The lack of technological advancement in this regard also affected data safety, data analysis and visualisation to engage with the collected data and derive meaningful insights. Furthermore, due to the use of paper-based systems, work burden was reported by most EHPs (n=95; 90.5%) from data collection to the duplication of data recording as well as work duties, parallel reporting, tedious data collation, insecure data storage, limited accessibility and sharing of data, manual data analysis, less use of data visualisation tools, and data quality issues. The perception of the work burden was found to be negatively affecting the use of data for decision-making (p=0.038; Rho=-0.203) by the EHPs. The EHPs were requested to indicate their level of satisfaction with developments or advancements in their institutions towards the digitalisation of working systems and improving their data management systems to enhance the provision of EHS and embrace the Fourth Industrial Revolution. On a five-point Likert scale, the results revealed that most (n=70; 66.7%) participants were not satisfied at all, 10.5% (n=11) was slightly satisfied, 12.40% (n=11) was moderately satisfied, 7.60% (n=8) was satisfied and 2.90% (n=3) was very satisfied. These responses show that from the EHPs' point of view, there was overall little progress in their municipalities on the digitalisation of Environmental Health data management. To go further to get an understanding of the lack of digital developments in Environmental Health data management. The participants were requested to indicate their challenges and concerns on the adoption of digital tools for data management in their municipalities. The participants were provided with a pre-determined list to select their responses from, and they were allowed to select all answers that apply to their cases, as well as the option to specify any other desired response. The lack of financial and material resources for digitalisation was selected by the most (n=83; 79%) EHPs. Sixty-four (60.9%) EHPs selected the lack of commitment from the executives of their municipalities. The lack of commitment from the departmental management was selected by 48 (45.7%) EHPs. The lack of necessary technical equipment to collect data during technical assessments was also selected by 64 (60.9%) EHPs. From 11 municipalities, four municipalities had plans and evidence in place for the enrolment of digital systems for Environmental Health data management. However, there were other projects within the studied municipalities that were on digitalisation. One municipality was digitalising their complaints management system. Four municipalities were using digital systems for Performance Management and Development, as well as for Service Delivery Budget and Implementation Plan reporting and monitoring. Another municipality was drastically implementing a workplace modernisation programme to digitise many paper-based operations and improve operational efficiencies, but there was no progress with digitalising their Environmental Health data management system. Another municipality was found to have an electronic Environmental Health Management Information System, that was able to capture data, store it and generate reports, amongst other functionalities. However, capturing of data was not conducted on-site in real-time, it was found that EHPs capture data at the office, after coming back from conducting Environmental Health inspections and investigations. Another municipality was rolling out a training to sub-district managers on Web-DHIS, to leverage its existing capabilities. The interviews in this study reflected that in comparison to other municipal programmes, digital transformation in EHS was very slow, and non-existent in other municipalities. Demonstrating that the modernisation of Environmental Health data management was not receiving the same energy and attention, compared to other

sections in the municipalities. These results indicate the lack of prioritisation and keenness for the digitalisation of Environmental Health data management by all the municipalities, as a big challenge. This is concerning, in the times when the returns on investment to digitalisation are guaranteed in terms of reducing printing and paper costs, as well as improving data availability, completeness, timeliness, quality, and promoting data use for decision-making (Stoumpos, Kitsios & Taliaset, 2023).

Use of Environmental Health Data for Decision-making

At an operational level of the provision of EHS in the studied municipalities, this study found that the culture of the use of data existed amongst most EHPs (n=87; 82.8%). This culture emerged amid dissenting factors like the work burden from data collection (p=0.038; Rho=-0.203), as well as a lack of technical tools and smart handheld devices to automate manual data management processes. Amongst the EHPs in this study, significant relationships were found between the use of data and their engagement in data analysis (p<0.001; Rho=0.504), as well as data integration (p<0.001; Rho=0.323). Indicating the potential power of data-driven insights to inform plans and decisions, even at an operational level. This supports the call which suggests that the power of data should be first demonstrated where it is produced (Shiferaw et al., 2017). At the middle management, the use of Environmental Health data was found to be moderate. Managers demonstrated a positive attitude and understanding of the power of data towards improving service delivery and enabling better health outcomes in the community. This is based on data use opportunities they presented to be leveraged in the provision of EHS. It is reported that these opportunities are instrumental to improving service delivery and making an impact in the community, in terms of enabling better health outcomes. Even though their maximisation relies on individuals as well as their organisations. These opportunities include data-informed policy development, improved institutional management and governance, use of data for risk management and emergency preparedness, targeted interventions design and implementation, programme performance monitoring and evaluation, stakeholder engagement, and intersectoral collaborations. Even with the availability of these opportunities, managers indicated that EHS generates a lot of data, but few elements of data get recorded to the EHIS and as a result, used for decision-making. This finding is consistent with what most of the EHPs revealed, as they indicated that their supervisors use the data sometimes (n=42; 40%). Other EHPs indicated always (n=9; 8.6%); often (n=17; 16.2%), rarely (n=20; 19%), and never (n=17; 16.2%). These results indicate that most EHPs were not satisfied with the use of data by their supervisors. At an executive level, it was found that most of the EHPs did not see enough evidence in their settings to indicate that their senior managers were using data effectively in decision-making. Based on that just 4.8% (n=5) indicated that they think their senior managers always use data for decision-making. Often was indicated by 10.5% (n=11), sometimes by 19% (n=20), rarely by 42.9% (n=45) and never by 22.9% (n=24).

Discussion

The findings of this study demonstrate that Environmental Health data management requires to be digitalised and modernised, to improve the use of data for decision-making that is impactful in public health. It can be postulated that the lack of modern technical tools and smart hand-held devices compromised the effective delivery of EHS. This corroborates with the statement which outlined that the use of paper-based data management systems in Environmental Health is a challenge for many public health issues to be addressed as informed by data (Wright & Street, 2016). Hence, a new approach is required. However, there is slow progress towards the digitalisation and modernisation of Environmental Health data management in the studied municipalities. This is due to the lack of allocated budget and commitment from the management of the municipalities for this digital transition. Automation of manual processes and improvement of operational efficiencies can free up a lot of time from administrative functions and burdens to technical functions, enabling enough time for the application of a scientific approach in the provision of EHS. As a result, a call for digital transformation in Environmental Health data management in South Africa emerged from this study. It was indicated that a system that should be a single source of truth for Environmental Health data in the country and enable a comprehensive report on the state of Environmental Health in South Africa to be generated is required. As it was found that because of insufficient data and poor coordination, it is a massive and complex exercise to collate all the relevant data and develop a national state of environmental health report in South Africa (Wright & Street, 2016).The adoption and implementation of digital technologies in Environmental Health data management can promote the power of data as a critical asset for decision-making and enhance the provision of EHS. This aligns with modern practices in public health informatics where data-driven decisions are pivotal for effective health interventions (Yogesh & Karthikeyan, 2022). With the emergence of public health threats like climate change-related disasters, pandemics, proliferation of vectors, food safety incidences, poor air quality and water pollution, agile public health interventions are required, using data at a centre stage (Chersich & Wright, 2019; Shezi et al., 2019). A digital

Environmental Health data management system therefore can be instrumental for environmental health surveillance and monitoring, and to facilitate targeted public health responses.

In the provision of health services, the use of routine health data at all levels is essential for decision-making to ensure effective and efficient service delivery to the community (MEASURE Evaluation, 2019; Sako et al., 2022). Dash et al. (2019) mentioned that the use of routine health data is key for health institutions to be better run and deliver the best outcomes. Hence, in the development of operational and strategic plans, insights that have been derived from routine health data must be included, to show their relevance and responsiveness to issues to be addressed. In routine work at an operational level as well as at the strategic level, decisions should be based on data-driven insights. Data need to be considered in setting goals and objectives, as well as developing strategies to meet them (Chauhan et al., 2022). In a study that was conducted on management information, it was postulated that when it comes to decision-making, data-driven insights must be used to respond to threats and opportunities by weighing alternatives and choosing a course of action to produce desired outputs and meet set goals (Ngqungqu, 2014). To support this statement, the findings of this study indicate that there was a culture and a positive attitude amongst EHPs and managers on the use of Environmental Health data. Even though evidence suggests that the use of data for decision-making was moderate at a middle-management level and perceived minimally at an executive level. Demonstrating unmatched enthusiasm and cultural practice, between the practitioners, middle management and the executive. Identified dissenting factors against the use of data at the operational level were the administrative burden from data collection, as well as the lack of technical tools and smart handheld devices. Similarly, in a report on the design and implementation of health information systems, these factors were identified as barriers to the effective use of data from routine health information systems (Tull, 2018). The findings of this study further revealed that the EHPs understood the importance of the use of data in EHS, to identify risks to human health and the environment, evaluate them, and prevent and develop control measures. Associated opportunities that can be leveraged in the provision of EHS for the betterment of human health, were also understood. However, a need for improvements in the use of data to inform decision-making was observed. The participants indicated that interventions in this regard can include continuous in-service training, provision of technologically advanced devices and information systems, adequate funding and regular discussions on data management. Technological advancements are fundamentally shaping how various health services are provided by the health sector (Manyazewal et al., 2021). In the meantime, data has become the bedrock upon which successful organisations are standing on, through harnessing the power of data to make informed decisions. All these developments play an ever-increasing role in providing sustainable solutions to improve operational efficiencies and strengthen health services (WHO, 2021). Through the digitalisation of Environmental Health data management and the promotion of the culture of data use, the following opportunities can be leveraged in the provision of EHS:

Improved Environmental Health data management: The introduction of digital technologies in Environmental Health data management and the use of smart devices provide an opportunity for seamless data collection and reporting, improved data quality, elimination of duplication in data reporting, reduced work burden on practitioners, as well as safe record keeping and cloud-based data storage. Furthermore, digitalisation in this regard can enable data to be available in real-time data, for analysis, interpretation and presentation of data-driven insights to make quick decisions in the provision of EHS.

Improved Environmental Health surveillance and monitoring: With real-time data from Environmental Health surveillance and monitoring, environmental health risks such as outbreaks, disasters and environmental pollution can be early detected by interpreting data-driven trends and patterns, to respond with necessary Environmental Health interventions in an agile manner (Coleman & Delea, 2013). Centralised data with geographical locations can also be used to improve Environmental Health compliance monitoring, using data mapping. This can enable the pinpointing of areas that are of concern and in need of specially targeted interventions. All these capabilities can be made possible through the adoption of digital and Geographic Information Systems technologies.

Enhanced multi-sectoral partnerships and collaborations: Digitalisation of Environmental Health data management can promote public-private partnerships, community engagements and collaborations with various public entities through data sharing and data integration. These partnerships and collaborations can allow stakeholders to learn from each other, collaborate on shared priorities and integrate services to address cross-cutting issues. Data sharing and integration can allow the combination of datasets from different sources and stakeholders using data analytics technologies to better understand the link between various environmental factors and the health of the people.

Promotion and strengthening of environmental health research: The centralisation and digitalisation of Environmental Health data provides an excellent platform for practitioners and researchers to source data and conduct

research. In this case, research can be used to probe many challenges and inform Environmental Health practice based on contemporary evidence using high-quality data from a digital system.

Improved institutional management and governance: Through the automation of many manual and paper-based processes, digitalisation provides an opportunity to enhance the efficiency of operational processes, and in turn, improve the pace of service delivery. This is also reliant on the effective use of data for operational and strategic planning, policy development, allocation of resources, and performance monitoring and evaluation.

Conclusion

In this study, the importance of improved data management and use in the provision of EHS to ensure that people live, play and work in safe and healthy environments, was shown. It is evident that more efforts are required to enable the use of data to provide Environmental Health intelligence in municipalities, provinces, and the country. The digitalisation and modernisation of Environmental Health data management have been shown in this study to be a requirement to embrace the digital paradigm shift in society and leverage all presented opportunities. At the fast pace of digital transformation in society, it is about time for EHS to also embrace digitalisation as part of modernisation and strengthening progressiveness and prosperity.

Declarations

Author Contributions: Conceptualization, S.S.M., M.F.S. and N.N.; methodology, S.S.M., M.F.S. and N.N.; validation, S.S.M., M.F.S. and N.N.; formal analysis, S.S.M.; investigation, S.S.M.; resources, S.S.M.; data curation, S.S.M.; writing—original draft preparation, S.S.M.; writing—review and editing, S.S.M., M.F.S. and N.N.; visualization, S.S.M., M.F.S. and N.N.; supervision, M.F.S. and N.N.; project administration, S.S.M. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest: The authors declare no conflicts of interest.

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