

Strengthening capacities of multidisciplinary professionals to apply data science in public health: Experience of an international graduate diploma program in Peru

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ABSTRACT

Nowadays it is necessary to strengthen health information systems and data-based solutions. However, there are few graduate training programs in Peru to use tools and methods of data science applied in public health. This article describes the development process and the initial assessment regarding the experience of the participants in an international multidisciplinary diploma in data intelligence for pandemics and epidemics preparedness, which was carried out from January to May 2021. The diploma was structured in 7 modules and 40 Peruvian professionals participated, of which 11 (27.5%) were women, and 16 (40%) came from regions outside of Lima and Callao. We discussed the need to strengthen institutional and health professionals' capacity to adequately manage large volumes of data, information, and knowledge through the application of emerging technologies to optimize data management processes to improve decision-making in health.

1. Introduction

Digital health tools are becoming important and are being included in Latin American health systems, including those linked to artificial intelligence for the improvement of medical care [1–2]. So, artificial intelligence has enabled to raise the level of application of the knowledge about healthcare using algorithms for performing the healthcare processes. For example, it helps the analysis of medical images that can be partially carried out by algorithms trained by specialist professionals without requiring their participation for initial alerts and multiplies the coverage of medical care to a larger population, thereby proposing a change in the medical care model from a reactive to a proactive one, focusing on health management instead of treating diseases. This is expected to result in fewer hospitalizations, fewer face-to-face medical consultations, and fewer treatments. Some experiences of data intelligence training programs have been described in Latin America, Africa, and Asia, including remote and face-to-face training [3–4], but much

more is needed in the context of the COVID-19 pandemic. Collaborative alliances are needed to provide educational services and greater access to them [5–6].

An app used in Peru during the pandemic was “Peru in your hands” that shows a heat map with red circles in the areas with infected people and with orange circles in those with people with described COVID-19 symptoms [7–8]. Other institutions as the Medical College of Peru developed apps such as the tool for COVID-19 self-evaluation (<https://www.cmp.org.pe/auto-evaluacion-covid-19/>) that determines if a person have to take a COVID-19 test; another app was “Escudo Sanitario Peru” (<https://www.cmp.org.pe/escudo-sanitario-peru/>), which is a self-declaration and visualization tool that allows knowing the situation of medical and health professionals during the COVID-19 pandemic [9].

In Peru there are few graduate training programs that use tools and methods of data science applied in public health, and to the best of our knowledge, there are not training programs about data intelligence

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applied in the health sector. By using the term “data intelligence” we mean, as suggested by Safhi et al. [10], to transform data into information, information into knowledge and knowledge into value. It refers to the intelligent interaction with data in an enriched and semantically meaningful way, where data is used to learn and obtain knowledge [10].

However, there is an urgent need for trained human resources and that develop proposals and interventions that help decision making in health during the COVID-19 pandemic. That is why the National Council of Science and Technology (CONCYTEC in Spanish), through the training programs in response to COVID-19 (<https://www.fondecyt.gob.pe/convocatorias/becas/proyectos-especiales-modalidad-programas-de-capacitacion-en-respuesta-al-covid-19>), called for structured proposals on the response to the emergency caused by COVID-19 pandemic and emphasized the need to strengthen and reinforce the skills of professionals in knowledge of science, technology and technological research, as well as health management and use of information technologies, aimed at providing effective and prompt solutions for the needs arising as a result of the pandemic.

In response to that need, the Graduate School at Universidad Continental was funded by CONCYTEC to organize an international multi-disciplinary diploma in data intelligence for pandemics and epidemics preparedness, that was carried out from January to May 2021. This article describes the development process and assessment regarding the experience of the participants in the diploma program.

2. Development of the diploma program

The diploma was funded by the National Fund for Scientific and Technological Research and Technological Innovation -CONCYTEC to strengthen and reinforce the training of human resources with a high level of quality and specialization, through the development of a training Diploma program, aimed at providing effective and timely solutions in response to the pandemic. It was organized by Universidad Continental and was carried out between January and May 2021. The structure of the diploma in data intelligence is shown in Fig. 1.

3. Diploma focus

The conceptual proposal for the diploma was designed taking in consideration the need to generate a new professional profile for health care attention during the next decades [11–12]. This includes a critical mass of multidisciplinary profiles. The idea of health professionals only trained under medical residence, without knowledge of the potential of

current technological tools is no longer possible. Neither does the idea of informatics or algorithmic without training in the characteristics of epidemiology and medicine. The new profile conceives professionals who are knowledgeable of key aspects to solve real problems. The real cases, especially those to deal with the COVID-19 pandemic, have specifically challenged the ability of the society to build multi-skilled teams [13].

Another axis was the access to real tools with algorithms that can be used by the participants, and not only teaching algorithms theoretically. In this sense, courses were created to share a gradually increasing depth in access to algorithms, and these courses were from those that describe general concepts to those that apply the concept to specific cases related to epidemiology, starting to apply Python interactive notebooks with Google’s Colab platform to make them a method that was used from the application of algorithms in complex models to algorithms of artificial intelligence, including the most basic models of classification and regression, to the “deep learning” algorithms as neural networks [14–16]

4. Selection of participants

Of the more than 200 candidates who expressed their interest in the course, 194 submitted applications and finally 40 students were accepted after a rigorous selection process. Applications were submitted on line and was directed to Peruvians with a high academic level or professional degree, good professional and/or research profile. In addition, applicants submitted an essay about data intelligence for pandemic/epidemic preparedness. Two faculty members from Universidad Continental carried out the selection of participants. Full scholarships were offered to selected participants. The web page of the program is available in: <https://posgrado.ucontinental.edu.pe/educacion-ejecutiva/programas/programa-de-capacitacion-en-inteligencia-de-datos-para-preparacion-ante-pandemias-y-epidemias>.

5. Program structure according to areas

The diploma program was structured into four components: Epidemiology and Public Health; Health Services and Information Systems; Data Science and Artificial Intelligence; and Global Health, ethics, and new technologies (Fig. 2). The components of the diploma program were based on models and good practices of international programs [17], including those developed by Skrzypek [18], Banack [19], Intawong [20] and Erundu [21].

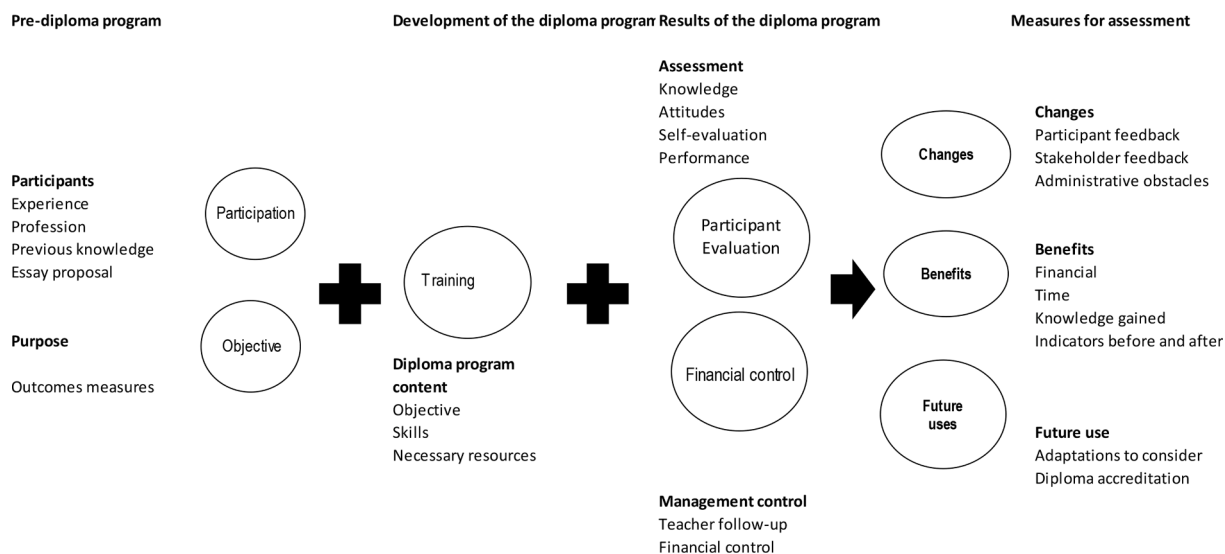


Fig. 1. Model of the Diploma Program in Data Intelligence.

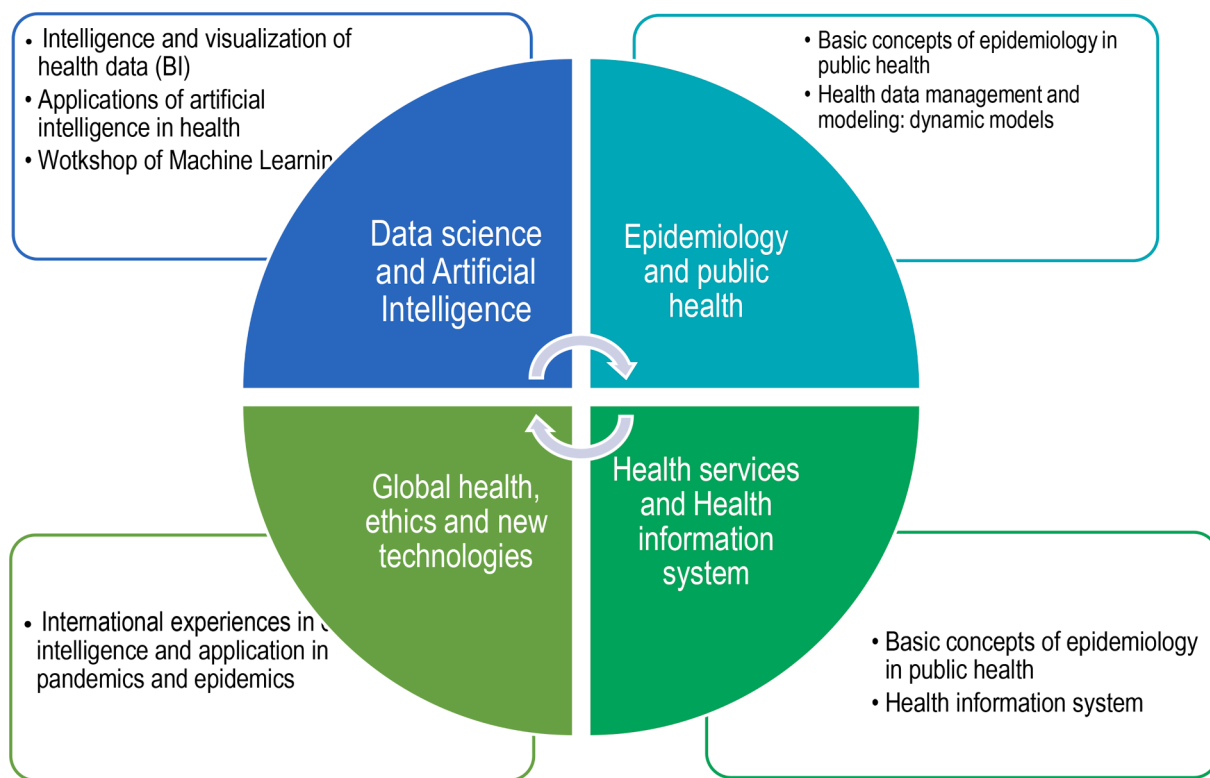


Fig. 2. Structure of the model of Diploma Program in Data Intelligence.

6. Development of learning modules

A series of seven learning modules was developed to the participants of the diploma program, and are the following:

- Module 1: Basic concepts of epidemiology in public health.
- Module 2: Health data management and modeling: dynamic models.
- Module 3: Health information systems.
- Module 4: Intelligence and visualization of health data.
- Module 5: Application of Artificial Intelligence in health - Machine Learning: Identification of numerical patterns, texts, and images.
- Module 6: Workshop: SIR Model - Python: Concepts and applications.
- Module 7: Workshop: Machine Learning and epidemiological patterns.

Complementary to these modules, four workshops were developed with international speakers who shared experiences on the following topics: Experience in data intelligence in Asia, Data Visualization and bioinformatics focused on the study of COVID-19, Experience in data intelligence in Latin America and Ethics in new technologies in the context of COVID-19.

In addition, two complementary international webinars were carried out and were open to the general public. The first one named: "COVID-19: data or data-driven epidemic" was carried out at the beginning of the program (<https://bit.ly/3mJ7MAI>) and the other one named: "Role of Data Management and Information Systems in times of COVID-19" (<https://bit.ly/2Yg8E5v>) was carried out at the end of the program. The diploma program was taught by eleven faculty members from Universidad Continental and six faculty members from international universities. Universities and foreign entities that collaborated with this diploma program were: the University of Washington (United States), the Pan American Health Organization (United States), the Center for Research in Health Systems of the National Institute of Public Health of Mexico, Oberta University in Catalunya-Spain, Autonomous University

of Baja California of Mexico, Fundación Universitaria del Área Andina of Colombia, International Institute of Socio-epidemiology in Kyoto-Japan, Stanford University (United States), University of Utah (United States) and Universidad Autónoma of Chile.

7. Assessment process of diploma program

Assessment was part of a permanent process. The achievement of competencies and program contents were verified. To validate the grades obtained, it was required to have at least 80 % attendance in the course. After finishing each module, participants completed a questionnaire with rating questions using the Likert scale and open-ended questions where participants could comment their perception about the quality and usefulness of the course and its individual modules.

In the analysis, descriptive statistics were used to sum up the course. Inferential tests and measures of effect size were used to assess knowledge enhancement for modules. Measures of effect size are useful to assess and interpret the magnitude of knowledge change. The scores of the pre- and posttests were entered into computer files using the Statistical Package for Social Sciences (SPSS-21 version).

8. Characteristics of participants in the diploma program

Of 40 participants, 11 (27.5 %) were women, 16 (40 %) came from regions outside of Lima and Callao (Table 1).

9. Knowledge assessment in modules

According to the structure of the diploma program, the mean score in each module were: Epidemiology and Public Health (M1 Basic concepts of epidemiology in public health: 14.4+/-2.2), Health Services and Information Systems (M2 Health data management and modeling: 17.5+/-3 y M3 Health information system: 16.4+/-2.8), Data Science and Artificial Intelligence (M4 Intelligence and visualization of health data (BI): 15.7+/-3.4, M5 Application of Artificial Intelligence in health:

Table 1
Socio-demographic characteristics of the participants.

Participants	n (%)
Health personnel	22 (55 %)
Non health personnel	18 (45 %)
Place of origin	n (%)
Lima and Callao	24 (60 %)
Regions out of Lima and Callao	16 (40 %)
Institution of origin	
Public	20 (50 %)
Private	20 (50 %)

13.3+/-5.04, M6 SIR Model - Phyton: 14.5+/-3.3 y M7 Machine Learning and epidemiological patterns: 15.5+/-3.6).

There were statistically significant differences in the performance of the participants at both the beginning and the end of the modules, as well as in the specific modules of Data Intelligence, both with $p < 0.05$ (Table 2).

10. Assessment of the satisfaction with the diploma program

The 40 participants answered a questionnaire at the end of each module. The score of each module considered a range from 1 (very bad) to 5 (very well). The mean score of satisfaction with the diploma program was 4.37. A student commented on its perception of the acquired knowledge in the diploma program: "I knew the importance of considering the data intelligence for decision making, but this diploma program allowed me to improve my skills, and contribute with my experience into feasible solutions to problem solving" (Table 3).

11. Research proposals generated during the program

All the students were required to present a research proposal to graduate from the diploma program:

- SISCOVID system, proposal to improve the amount of demand for COVID-19 tests at the national level.
- Strengthening the network of Health Technology Assessment in the context of COVID-19.
- Information System in the "Hospital Nacional Docente San Bartolomé" in the context of pandemic.
- Information System where the number of hospital and ICU beds available is displayed in real time.
- Use of web scraping method to obtain data and develop a historical registry of the prices and points of sales of dispensable medicines for COVID-19.
- Optimization of the process of collection and processing of information in the context of a pandemic at the National Institute of Statistics and Informatics (INEI in Spanish)
- Use of algorithms of recurrent neural networks applied to time series data to improve response capacity in disease prevention of the National Center for Epidemiology, Disease Prevention and Control and the Ministry of Health.

These proposals were presented to coordinating faculty member of the final diploma course (JCM) and it is planned that the best proposals

Table 2
Differences in the performance of the participants in the pre- and post-tests in the diploma program.

Modules	Pre-test mean % (SD)	Post-test mean % (SD)	z ±	p
I and VII	14.4 (2.2)	15.5 (3.6)	-2.037	0.042
III and VII	13.3 (5.04)	15.5 (3.6)	-1.938	0.05

± All test U Mc Whitney are significant with $p < 0,05$

Table 3
Follow-up assessment by the participants of the diploma in data intelligence.

Componente	Mean
Methodology	4.34
Assessment	4.33
Professional performance	4.41
Material and contents	4.35
Module	4.32
Academic services and virtual platform	4.5
Mean	4.37

can apply for financing to be carried out. It is important to highlight that one of the student that finished the program, together with a team of professionals from the "Seguro Integral de Salud (SIS)", won the "Dataton" to prevent the third wave, with the Digital Project "Geovac Peru". The "Dataton" was a virtual event organized by the Ministry of Health and the Presidency of the Council of Ministers, in alliance with the National Council of Science, Technology and Innovation and was carried out in August 2021.

12. Results of the diploma program

In general, the participants described the course as a very well experience. These comments were collected from the performance assessments of each module. In addition, the students highlighted to the modules of data science and artificial intelligence as the most relevant ones. Data science and artificial intelligence offer new hope for anticipating, preventing, and combating the threats of infectious disease outbreaks, as well as facilitating the understanding of population behavior during pandemics, such as the COVID-19 health crisis [22–23].

The way how the program was carried out was a very important aspect. These results agree with the studies of Gerhart et al. [24], Tuma [25] y Wilcha [26] who described the importance of team projects, the use of technology in the training and the effectiveness of the virtual training. The modules structured in the diploma program in data intelligence contributes to the capacity building of participants, to promote research considering the health needs and was adapted to the pandemic context through a digital ecosystem that allows students a valuable interaction based on a novel educational strategy, even more in a virtual environment [27–28].

In the context of the COVID-19 pandemic, there is a need to address the health problems in a different and innovative way from the perspective of both the offer and demand of health services, to have capable staff and to develop problem-solving and decision-making skills. In addition, governments should promote open data policy and the implementation of open data repositories not only as an accountability mechanism, but also as promotion of the generation of new knowledge, such as "digital surveillance" or "digital epidemiology" and the development of research [29–30].

Some interventions and research proposals by the students were tracking the spread of virus, predicting its evolution, the importance of the Health Technologies Assessment and combating future outbreaks, among others.

We consider that it was beneficial to include both Peruvian and international entities to offer a best overview of the global situation in data management and data science through different experiences in Latin America [31] and good practices around the world. In addition, the Pan American Health Organization [32] in its recent "Policy on the Application of Data Science in Public Health Using Artificial Intelligence and Other Emerging Technologies" approved in the 168 Executive Committee Session (May 2021), stated as an important action to incorporate data science in public health, the establishment of "partnerships through a network of institutional and individual experts throughout the Region, with special attention to subregions".

The Pan American Health Organization proposes to incorporate the

“centers of excellence” and specialists in data science that already exist in the region, and to create a forum for the interdisciplinary participation in all the aspects of the public health that are directly and indirectly with the health sector. In addition, the policy related to the application of the data science establishes an “assessment and a capacity mapping in the countries within the health and other sectors, the academic institutions and the private sector to determine existing data science expertise and potential immediate opportunities to build data science capacity and network” [32].

For future editions of the diploma program, the possibility of internships at national and international institutions, financing and project incubation, mentoring programs, scientific article writing workshops, and a more interactive virtual platform will be explored, as suggested by previous studies [33].

The outcomes of this study suggest that universities should place great emphasis on facilitating and improving the efforts made by faculty and researchers, monitoring the evaluation methods, and developing the most appropriate learning resources to complement each module of the program.

In conclusion, we present the first report of an international diploma program in data intelligence for pandemics and epidemic preparedness in the context of the COVID-19 pandemic in Peru. The structure and the model of the diploma described in this article can be used as a reference for similar training programs related to the application of the data science in public health at the national and international level.

Author contributions

AGA and WHC conceived the Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. All authors writing – original draft and writing – review & editing.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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To all the students, the Peruvian and international faculty and the coordination team of the diploma program, who allowed us to successfully achieve the objectives.

Summary Table

What was already known on the topic	What this study added to current knowledge
The Pan American Health Organization proposes to strengthen institutional and health worker capacity to employ data science tools and methods, and to properly manage big data, information, and knowledge through the application of emerging technologies to improve health-related data management and to	This is the first report of an international diploma program in data intelligence for pandemics and epidemic preparedness in the context of the COVID-19 pandemic in Peru. Participants described the diploma program as a very well experience and

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What was already known on the topic	What this study added to current knowledge
support decision-making. In Peru, there are few graduate programs that use tools and methods of data science applied to public health.	students highlighted the modules of data science and artificial intelligence as the most relevant ones.

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