

## SERVICE FOR MONITORING THE CONDITIONS OF VACCINATION OF THE POPULATION AGAINST CORONAVIRUS INFECTION

*Zakharii-Andrii Feshchenko, Iryna Yurchak*

*Lviv Polytechnic National University, 12, Bandera Str, Lviv, 79013, Ukraine.*

*Authors' e-mail: zakharii-andrii.feshchenko.mkisp.2021@lpnu.ua*

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**Abstract:** Health care is a system of measures aimed at ensuring the preservation and development of physiological and psychological functions, optimal performance and social activity of man at the maximum biologically possible individual life expectancy. The key goal of any health care system is the availability and quality of medical care, medical services, medical care. The main goal of any country is to build an effective model of the health care system and achieve the highest level of public health with minimal resources.

The purpose of developing a service to monitor the vaccination status of the population against coronavirus infection is to help users learn information about vaccination and general statistics in the country on vaccinations. This system is suitable for both qualified medical users and users who are unfamiliar with medicine but want to know more about vaccination data.

The article attempts to analyze the types of services for vaccinations and their alternatives. It describes the principle of operation of the vaccination service in the form of a report made on the application platform for visualization of Microsoft Power BI Desktop.

**Index Terms:** Cloud Service, Report, Script, Vaccinations, Microsoft Power BI.

### INTRODUCTION

Health care or healthcare is the maintenance or improvement of health via the prevention, diagnosis, treatment, amelioration, or cure of disease, illness, injury, and other physical and mental impairments in people. Health care is delivered by health professionals and allied health fields. Medicine, dentistry, pharmacy, midwifery, nursing, optometry, audiology, psychology, occupational therapy, physical therapy, athletic training, and other health professions are all part of health care. It includes work done in providing primary care, secondary care, and tertiary care, as well as in public health.

Health is an indisputable value.

Health care-branch of activity of the state, the purpose of which is the organization and provision of affordable medical care. Health care is a key element of national security [2 – 4].

Health became especially important during the global COVID-19 pandemic. Unfortunately, according to statistics, Ukraine, like other countries, was not ready

for this type of disease. Although, according to the same statistics, our state has avoided high mortality, in contrast to the leading states, because in the post-Soviet space, in particular in Ukraine, vaccinations were and are carried out in several stages after the birth of a child. And one of the main methods to prevent the spread of this disease is vaccination.

Vaccination is the administration of antigenic material to generate immunity to an infectious disease that prevents infection or mitigates its adverse effects. The process of vaccination is shown in Fig. 1 [5 – 6]. As antigenic material used:

- live but weakened strains of microorganisms or viruses;
- killed (inactivated) microbes;
- purified material, such as proteins of microorganisms;
- synthetic vaccines.



*Fig. 1. The process of vaccination against coronavirus infection*

Vaccine is a preparation made on the basis of weakened or killed pathogens, products of their vital activity or their synthetic analogues. Currently, computer methods are used to develop vaccines based on data (data banks) of genomic sequences of many bacteria, pathogens of parasitic infections and viruses. The administration of the vaccine mimics a disease that allows the body to identify the pathogen and “learn” to fight the pathogen by producing specific antibodies [7–8].

This technique allows the body to prepare for a possible encounter with the “real” pathogen and to ensure an easier course of infection, if it occurs. The example of the vaccine versus coronavirus infection is shown in Fig. 2.



Fig. 2. Vaccine against coronavirus infection

#### THE NEED TO USE SERVICE FOR MONITORING CONDITION OF VACCINATION OF POPULATION

This system is relevant because, living in such a difficult time, it is important to always have real data, so as not to look uneducated and not to misinform others. The COVID-19 pandemic, which is raging not only in Ukraine but also around the world, has made this clear. Because, if before, people were reluctant to believe the statistics that was provided to them, then against the background of this virus, the situation has only worsened. This service will take data that can be trusted, because one of the reasons why Ukraine is still among the countries with the lowest percentage of vaccination among the population, even the first dose - is distrust of the information provided and fear for themselves. Therefore, the service will try to solve this problem, if not completely, then at least increase the percentage of vaccinations.

#### COMPARATIVE ANALYSIS OF EXITING SERVICES FOR VACCINATION TRACKING

With the start of vaccination against coronavirus infection, the statistics were different. Only one day there were some data, so the next day they became radically different, which undoubtedly misled people about the real situation in the country, which, in turn, repelled the idea of vaccination. With the advent of online alternatives, everyone can see what happened yesterday, the day before yesterday, or a week ago in the country. There are several: online service (or rather site) Health Systems of Ukraine, COVID-19 Vaccination, COVID-19 Vaccinations.

So, let's start with the most powerful - online service (or rather the site) of the Health Care System of

Ukraine, or rather one of its units, shown in Fig. 3, which is responsible for monitoring vaccination against coronavirus infection [9].

Number of patients vaccinated	9 868 953 (99.8%)
Number of patients reported not to have been vaccinated	14 101 (0.1%)
Number of patients for whom erroneous stocks are available	522 974 (5.3%)

Fig. 3. The unit of the Health Care site that is responsible for vaccination

According to Fig. 3, it becomes clear that the site is now in test mode, which means that it has good technical support and the data on it will always be valid (correct) and roughly depict the picture that is happening in our country. You can also note the legend of the site, which is shown to the left of the map, according to which you can easily go to the section that interests you and depending on your actions will change the data displayed on the maps, as well as different types of charts presented here to facilitate perception.

The next service I would like to consider will be COVID-19 Vaccination., shown in Fig. 4, which, like its Ukrainian counterpart, is designed as a site from Pharmaceutical Technology [10].

What immediately catches your eye is the ability to register or log in to the site (authorization). Because COVID-19 is not the main branch in which this company operates, but at the time of the pandemic, it became almost the core one for everyone. The data on this service are presented in a convenient format, although if you believe in Fig. 4, the last update was on April 30. This may indicate outdated data, as well as poor technical support for the resource. But I want to hope that this is either not for long, or a certain reason has been indicated on social networks. Also, if the level of your English is a bit lame, you will have to either completely translate the site, or guess what is written from the graphs and charts.

An unconditional plus is the information provided on the resource about different vaccines, the results of vaccination with a particular vaccine, the main symptoms after vaccination. Although, the information is presented in Table 1.

It will be more interesting for doctors who want to learn more about different types of vaccines, to be able to navigate and improve their knowledge to answer their patients' questions, if they arise.

And the last service I would like to consider will be COVID-19 Vaccinations from Oxford Martin School [11]. As the creators of the site say in their Data Explorer all can see full data about COVID-19 vaccinations (doses administered, people with at least 1 dose, and people fully vaccinated).



Fig. 4. COVID - 19 Vaccination site (map)

#### Coronavirus vaccine roll out statistics by country

Table 1

Country	Doses administrated	Doses per 1000
France	99 531 399	1 485.8
Iran	92 677 737	1 103.4
Italy	90 897 991	1 504.2
South Korea	79 718 850	1 543.9
Thailand	78 656 124	1 132.9
Bangladesh	75 557 364	468.3
Spain	72 410 731	1 549.8
Philippines	64 195 936	601.9
Argentina	61 652 681	1 385.6
Canada	59 088 388	1 594.4
Malaysia	50 213 960	1 558.1
Saudi Arabia	46 288 357	1 373.5

As we can see from Table 2, this service also has a sidebar with a legend, where we can select the criteria by which we want to see vaccination. If you look further, it is easy to see how the site is built: the creators seem to be talking to the public, answering the main questions that interest everyone: how many have already been vaccinated, how many doses per day, how many are fully vaccinated, etc.

The application is also made in English, but the information on it is updated daily. And most importantly, all the information, as well as charts, maps and graphs can be downloaded. Compared to the two previous resources, this has not yet happened.

Here, some benefits of this site:

- Daily data update;
- Good visualization;
- Ability to download data.

Table 2

#### Share of people vaccinated against COVID-19

Country	Int of fully vaccinated (in millions)	Count of partly vaccinated (in millions)
India	341.93	399.28
USA	192.40	31.23
Brazil	123.67	38.50
Indonesia	78.99	46.11
Japan	93.36	5.35
Mexico	62.16	12.77
Pakistan	44.43	30.19
Vietnam	28.78	32.07
Russia	49.57	8.42
Germany	55.81	2.14
UK	45.84	4.40
Ukraine	7.96	3.45
Nigeria	3.09	2.61

#### SERVICE COMPONENTS

To achieve the goal, namely to create a service for tracking the vaccination of the population against coronavirus infection, it should be implemented, like its predecessors in the form of reports. But in my case, it will not be a site, but a publication on a cloud service. The question arises: how will the data be uploaded to this report? In my case, it will be a script written in the Python programming language, which will, firstly, download data from the site with the data, store it on a local computer and allow it to be read in the application for creating reports - Microsoft Power BI Desktop. By the way, the latter is provided for free. But everything is in order.

#### ALGORITHM OF SERVICE OPERATION

Briefly about what is happening in the algorithm of this study: firstly, when you turn on the service Microsoft Power BI Desktop, you need to log in. In case of failed authorization, the system will ask you to either try again or reset the password or login (according to what the user forgot). After that, using a previously written script in the Python programming language, you need to download the data to be able to make visualizations (without a file containing tabular data you will not make visualizations, and I will remind that Power BI works only with tabular data). This algorithm is shown in Fig. 5.

After writing the script, and depending on the result that Power BI will present, you may find yourself at a crossroads: look for errors in writing script code or start working with data.

If there is a problem with the code, there may be several reasons why this script does not work (script):

- Problems on the server of the resource, where the data for analysis are taken (it is possible to work on the server or update the data);

- Mistakes in spelling (mostly Latin letters were written in Cyrillic and vice versa);
- Incorrectly configured Python, Microsoft Power BI Desktop (it's about configuring Python in the settings of the application for data visualization);
- No internet connection (this also happened, notoften, but still).

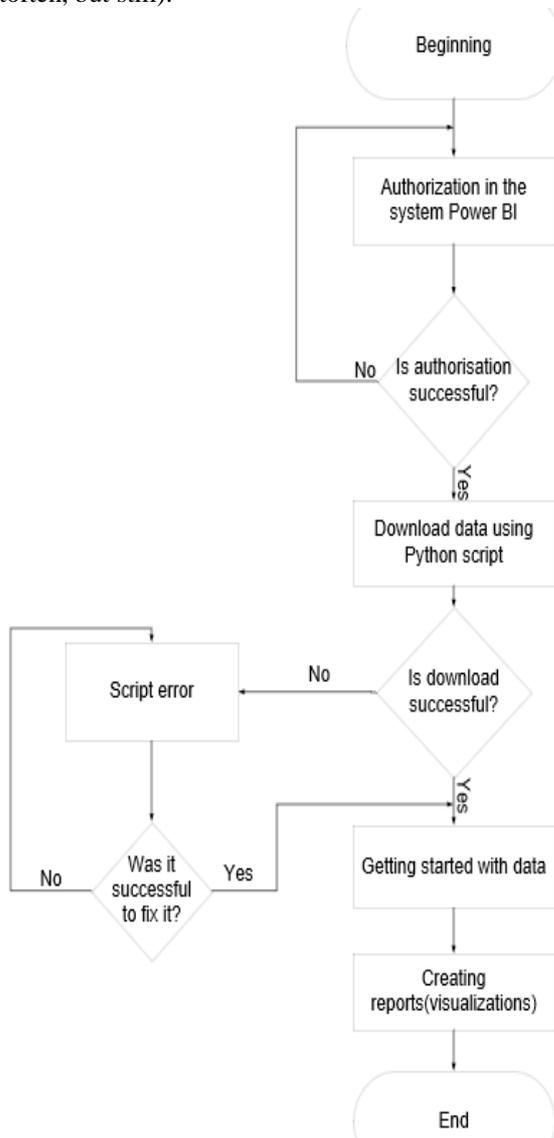


Fig. 5. Algorithm of service operation

### CLOUD SERVICE

First of all, web services are a technology [12 – 13]. And like any other technology, they have a fairly well-defined environment. If we look at web services in terms of the network protocol stack, we will see that it is, in the classic case, nothing more than another add-on over the HTTP protocol.

On the other hand, if we hypothetically divide the Internet into several layers, we will be able to distinguish at least two conceptual types of applications - computing nodes that implement non-trivial functions and applied web resources. At the same time the second

one is often interested in the services of the first one. But the Internet itself is heterogeneous, that is, different applications on different nodes of the network operate on different hardware and software platforms, and use different technologies and languages. To link all of this and allow some applications to share data with others, Amazon Web Service was used for this study. However, only 3 internal services will be taken from entire AWS, such as: RDS, EC2 and S3 as it is presented at in Fig. 6.

Briefly about the role of AWS in this study: firstly, a virtual machine will be created on the EC2 server, it will be downloaded using Python script data downloaded from the Internet, then this data will be converted into a database using RDS, and then open in Microsoft Power BI Desktop, which will create a report on the state of vaccination of the population against coronavirus infection, which will be stored in 2 copies: one on a local machine, the other on S3, which will serve as a data repository that will be accessed that others could view this report any time. And now more about each item [14].

Amazon Relational Database Service (Amazon RDS) allows to easily configure, use, and scale relational databases in the cloud. The service provides economical and scalable use of resources while automating time-consuming administration tasks, such as hardware allocation, database configuration, patch installation, and backup.

## Amazon Web Service



Fig. 6. Amazon Web Service and its main components

This allows applications to be focused on high performance, high availability, security, and compatibility.

Amazon RDS is available as a database instance of several types: optimized for memory, high performance, or I / O - and offers a choice of six well-known database cores, including Amazon Aurora, PostgreSQL, MySQL, MariaDB, Oracle Database and SQL Server. With the AWS Database Migration Service, you can simply migrate or replicate existing databases to Amazon RDS.

#### Benefits:

- Ease of administration;
- High scalability;
- Availability and reliability.

Amazon Elastic Compute Cloud (Amazon EC2) is a web service that provides secure scalable computing resources in the cloud. It helps developers by simplifying cloud computing across the Internet. The simple web interface of the Amazon EC2 service allows to access computing resources and configure them with minimal effort. It gives users complete control over computing resources, as well as Amazon's proven computing environment to work with [15 – 16].

Amazon EC2 offers a computing platform with the widest and most ready-made functionality, which allows to choose the processor, storage, network, operating system and purchase model. The fastest processors in the cloud are offered and are the only cloud space with an Ethernet network with a bandwidth of 400 Gbps. It has the most powerful instances based on graphics processors for the organization of courses on machine learning and graphical display of workloads, as well as instances with the lowest cost for each logical output instances in the cloud. AWS runs more SAP, HPC, machine learning, and Windows workloads than any other cloud.

Amazon Simple Storage Service (Amazon S3) is an object storage service that offers the industry's best performance, scalability, availability, and data security. This means that customers can be companies of any size and from any field of activity. They can use the service to store and protect any amount of data in various situations, such as data lakes, websites, mobile applications, backup and recovery, archiving, enterprise applications, IoT devices (Internet of Things) and analysis of large data [17].

Amazon S3 offers easy-to-use administration tools that allow to organize your data and fine-tune access restrictions according to business needs or legal requirements. Amazon S3 provides 99.999999999% reliability (here 11 nines) and stores the data of millions of applications for companies from around the world.

Benefits:

- Industry-leading performance, scalability, availability and reliability
- Wide choice of economy classes of storages
- The widest opportunities for security, compliance with legal requirements and audit
- Data control and access tools
- Query data without deleting and processing data on request
- Cloud storage service with better support.

#### PROGRAMMING LANGUAGE FOR SCRIPT

Python-interpreted object-oriented high-level programming language with strict dynamic typing was developed in 1990 by Guido van Rossum. High-level data structures, together with dynamic semantics and dynamic linking, make it attractive for rapid program development, as well as a means of combining existing components. Python supports modules and module packages, which promotes modularity and code reuse. The Python interpreter and standard libraries are

available in both compiled and source form on all major platforms [18 – 19].

A Python interpreter and a rich standard library (both source code and binary distributions for all major operating systems) can be obtained from the Python website [www.python.org](http://www.python.org), and can be freely distributed. The same site has distributions and links to numerous modules, programs, utilities and additional documentation.

Python is meant to be an easily readable language. Its formatting is visually uncluttered, and often uses English keywords where other languages use punctuation. Unlike many other languages, it does not use curly brackets to delimit blocks, and semicolons after statements are allowed but rarely used.

Among its main advantages there are the following:

- pure syntax (indents should be used to select blocks);
- portability of programs (which is typical of most interpreted languages);
- the standard distribution has a large number of useful modules (including a module for developing a graphical interface);
- the ability to use Python in dialog mode (very useful for experimenting and solving simple problems);
- the standard distribution has a simple, but at the same time quite powerful development environment, which is called IDLE and which is written in Python;
- convenient for solving mathematical problems (has the means to work with complex numbers, can operate with integers of any size, in dialog mode can be used as a powerful calculator);
- open source (the ability to edit it by other users).

As it is shown in Fig. 7, Python script downloads data from URL, saves it in the local machine and reads its inside tool, that is used to create visual reports which can be easily read and understood by users in the Internet. Now, a little more about the script itself.

```
import requests

url = 'https://data.gov.ua/dataset/4cced549-1a03-4e0b-afbb-46
f51566ef-dd6a-47f1-8827-6d5e5ca17fda/download/immunization_co
r = requests.get(url, allow_redirects=True)
open('C:/Users/zfs21/Desktop/immunization_covid19_2021.csv',
```

Fig. 7. Python script

The first line is responsible for connecting the requests library, which, as it has been mentioned earlier, allows to access URLs directly; the next line will be the link to the site with the data; the third line of the script provides access to redirects (links that often occur when you download a file from the Internet and when you click the download button, it redirects to an additional

tab from which you can choose which directory to save the file on your machine).

Then specify in which directory to store the file and open it accordingly there; and the last line is responsible for reading the CSV file in Power BI itself using the pandas library.

#### PROGRAMM FOR CREATING VISUALIZATIONS

Power BI can work easily and quickly, generating brief analytical information based on an Excel workbook or local database. However, Power BI is also a reliable enterprise-class product that is suitable not only for large-scale real-time modeling, but also for the development of individual solutions. In this way, it can act as your personal means of visualizing and maintaining reports, as well as serve as a subsystem of analytics and decision-making for group projects, offices or entire organizations. Power BI consists of a classic application for Microsoft Windows - Power BI Desktop, web service SaaS (software as a service), called Power BI, and mobile applications Power BI, available on smartphones and Windows tablets, as well as on Apple iOS and Google Android [18].

After all the settings and writing a script that will download the data to work in Power BI, you can start creating visualizations that will show all users the real state of vaccination of the population against coronavirus infection [19].

In total, 4 pages will be presented, which will reflect the state of vaccination: the first page will display vaccination data by age group, as well as by gender; the second page will contain general information on vaccinations in Ukraine; the third page will contain a map that will contain detailed information about the places where the population of Ukraine was vaccinated, on the third page there is a matrix by regions and cities, with more detailed information about vaccination.

As it will be shown in the figures below, it's easy to read such type of reports, because all of the information is displayed on the small blocks of visualization which used to show us different information about vaccination against COVID-19 in Ukraine.

But everything is in order. In Table 3 there is some information about age group of vaccinated Ukrainians in circle diagram in visualization, but good view is shown in table format here.

Table 3

#### Number of vaccinated according to the age group

Age group	Number of vaccinated
12 – 15 y.o.	6 851
16 – 18 y.o.	30 741
18 – 20 y.o.	631 841
20 – 39 y.o.	5 921 863
40 – 49 y.o.	4 219 300
50 – 59 y.o.	3 781 884
60 – 69 y.o.	3 042 075
70 – 79 y.o.	1 311 092
Over 80 y.o.	398 688

#### CONCLUSIONS

At the moment, it is difficult to imagine, let alone meet a person who does not know how to use, or never in his life went online. We can even say more: it has penetrated our lives. After all, today's man sometimes can't imagine his life without a daily dose of this digital injection. And the global situation with the coronary virus pandemic has made the situation even worse. After all, people are no longer able to distinguish untruth from truth on the Internet.

The same can be said about the data we encounter on the Internet or television on a daily basis. Any incorrect data or information can make people think wrong. Yes, falsely presented daily statistics on vaccinated, new cases of infection, false data on the vaccine push people not to trust anyone, especially the state and doctors. And, as a conclusion, make them reject vaccination.

According to the Ministry of Health of Ukraine, the level of public confidence in vaccination is still insufficient to achieve collective immunity, for this purpose at least 60% of citizens need to be vaccinated. Thus, in a study by the sociological group "Rating", it was noted that only 47% of citizens were ready to be vaccinated against Covid-19. At the same time, there was a certain logical inconsistency, as 71% of respondents believed that global vaccination would reduce the incidence in the world.

But no sources and services were untrue. They simply knew little about them and, did not want to dig into the truth, believe in the first better data. Vaccination tracking services were actually a good source of information that would allow to know at least a rough picture of what was happening and, if possible, tell others about it. It is right to say: properly informed means armed and able to refute false information.

By using this service, you can gain more knowledge about the situation in the country, convey this information to relatives, acquaintances, friends and not be afraid of vaccination and everything related to it. If you look at the statistics, any online service helps to absorb new data, to be aware of many events, sometimes without delving into the depth of the question, but this bribes with its simplicity and ease of use. The developed vaccination tracking service had high reliability, frequent technical support, daily data updates.

That is why services for tracking vaccinations against coronavirus infection are important and deserve to exist.

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**Zakharii-Andrii Feshchenko** has been receiving a Bachelor's degree since 2017. Now he is a fifth-year computer engineering student at Lviv Polytechnic National University.

His research interests include data processing, creating data-related visualizations and working with databases.



**Irina Yurchak** received the B.S. and M.S. degrees in Lviv Polytechnic Institute, Lviv, in 1987.

Her research interests include the work with Artificial intelligence systems, intelligent computing systems, neural networks, genetic algorithms, fuzzy logic, recognition systems, prediction problems, computer graphics, computer modeling and animation, web design.