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Covira: A COVID-19 risk assessment, visualization and communication tool

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A B S T R A C T

Assessing the possibility of Coronavirus infection and its risk on an individual’s life, estimating the spatial transmission risk based on the dynamic condition of a particular place into consideration, and communicating the same to the public is crucial for minimizing the potential impact of COVID-19. With the increase in cases world-wide, new patterns are being unfolded. Nevertheless, an application for risk assessment will not only help the researcher to quickly verify the proof of concept but also is a powerful tool to bring into notice the results immediately as one of the perfect tools for risk communication. Covira (https://covira.info) is an open-source web-based software that captures the response, calculates personal as well as regional risk, and displays the result to the end-user in the form of maps and risk cards.

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Code metadata

Current code version
Beta 0.5

Permanent link to code/repository used of this code version
https://github.com/ElsevierSoftwareX/SOFTX-D-21-00015

Code Ocean compute capsule
Not Applicable

Legal Code License
GNU General Public License family

Code versioning system used
GitHub

Software code languages, tools, and services used
PHP Laravel, Postgres Database, leaflet for map visualization, Regional risk modeling and mapping - R language

Compilation requirements, operating environments & dependencies
Apache or IIS web servers, preferably Postgres DB PHP v7 or above, Laravel v7 or above

If available Link to developer documentation/manual
https://github.com/er-beeps/covira#readme

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Software metadata

Current software version
V 0.5

Permanent link to executables of this version
https://github.com/er-beeps/covira.git

Legal Software License
GNU General Public License family

Computing platforms/Operating Systems
Linux

Installation requirements & dependencies
Since, it is web-based application, it does not have any installation/browsing dependency except for the thin client and an internet connection.

N/A

If available, link to user manual - if formally published include a reference to the publication in the reference list
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### 1. Motivation and significance

The coronavirus disease (COVID-19) originated from China towards the end of the year 2019 now has spread above 200 countries and territories around the world with more than 234 million cases, already claiming over 4.7 million lives and still counting [1]. Even though, there has been substantial progress in vaccination in different parts of the world [2], still bigger challenges await the manufacture of sufficient quantities and complex logistics of distribution with rigorous stock management and affordable price worldwide. Until then, assessing the risk, communicating it properly, and limiting the spread would be a major strategy. Data and software engineers have joined the force along with the frontline fighters to analyze the data, detect the pattern, assess the risk of infection and communicate it well to the citizens so that the consequence of the COVID-19 be minimized [3–5].

COVID risk assessment tools have been introduced for several purposes, mainly for contact tracing, people exposure and so on as listed in [6], however, the integrated tool for regional and personal risk assessment was not introduced. Disaster risk communication is often lacking in developing countries, there are some shreds of evidence from the Gorkha Earthquake 2015 disaster in Nepal [7]. A similar scenario has been observed during the initial phase of the pandemic. Nepal has introduced a nationwide lockdown on 24th March 2020 when it had traced an only couple of cases throughout the country. Such a blanket lockdown impacted severely in social to economic sectors [8].

A multidisciplinary approach for COVID-19 risk assessment and communication was conceptualized, a personal risk model was developed, a regional risk assessment framework was proposed to provide insight on different risk levels [9]. In addition to the theoretical models and framework, a risk communication tool has also been developed to enhance the dissemination of risk properly.

Visualization [10], machine learning [11–13] and statistical modeling [14], robotics [11], and contact tracing [15] has been the major focus of the engineers in the recent past that have helped slow down the spread of COVID-19 and reduce the moveability. Geostatistical modeling helps better understanding the disease trend and facilitates the informed decision-making process [16]. Building a mathematical model to predict the infection is easier a complex process as there is a number of variables to consider [17]. Moreover, a model developed for a person in a geographical location cannot be carried as it is to another place. It must be contextualized to several factors including but not limited to age, underlying health condition, exposure level, symptoms, distance to nearest healthcare facilities. Hence, more logical would be to develop a model that would assess the level of personal risk based on symptoms and behavior.

We have developed a web-based application that calculates personal risk in the form of probability of risk of life and individual infection. This is assessed by evaluating the responses against the online questionnaire fitted over the guiding relationships as follows in Eqs. (1) and (2) respectively, proposed by [9].

\[
\text{CRI} \% = Y \times \left[ \frac{(1 - z) + z \times \text{CRF}}{100} \right]
\]

(1)

Probability COVID-19 Infection = regional risk × exposure

(2)

where CRI represents the Covid Risk Index, ‘Y’ represents the age factor, and ‘z’ and CRF represent comorbidities factors. Regional risk of the area where the person lives is calculated from Eq. (3), exposure is a sum of the values depending on the activities, profession, etc. as provided in [9]. Next free and open-source software (FOSS) scripting language R is used to calculate the regional risk considering dynamic variables like the number of inward migrants, current COVID infected cases in the locality, a number of quarantined cases from abroad exposure, preventative measures are taken, etc. as shown in Eq. (3). The dynamic modeling tool provides an updated risk zoning every time the case is updated in the region. The Total Risk Score (TRS) of the region is calculated as a function of COVID transmission risk (CTR), public health risk (PHR), and socioeconomic risk (SER) as shown in Eq. (4). Where CTR, PHR, and SER themselves are a function of other factors
Fig. 2. The overall risk right after the peak of the first wave (a) and before covid (b).

provided by [9].

\[ CTR = 0.6 \times PCS + 0.1 \times QNT + 0.1 \times EXP + 0.2 \times POD \]  \hfill (3)

where, \( PCS = \) Positive case score
\( QNT = \) Quarantined people score
\( EXP = \) Community exposure score
\( POD = \) Population density score

\[ TRS = CTR \times \frac{(0.6 \times PHR + 0.4 \times SER)}{100} \]  \hfill (4)

Finally, personal risk scores and regional risk maps are communicated via an interactive web platform along with the personalized suggestion depending upon the category of risk each falls into. The web platform has a public view as well as the admin view. The weights to each factor in the questions are configurable in the admin view whereas the risk maps and suggestions are visualized in the public view with appropriate risk meters and color legends. Covira is developed following a modular, scalable, and flexible approach that works smoothly with a minor configurational change to fit any mathematical and empirical model. So, it can be used by the researchers as an assessment and visualization tool to validate their model and proof of concept.

The tool assesses the personal risk based on the personal health history, and exposure. In addition to this, the regional risk is also calculated based on the number of active cases in that region, population density, inbound travel along with socio-economic indicators such as access to the health facility, distance to market, human development index. A tool with geo-visualization of the risk considering both of the assessments is a first of this kind.

2. Software description

Covira is a web-based software bundle built over model view controller (MVC) architecture using free and open-source PhP (Laravel framework) and PostgreSQL database. A part of this software is a script written in R language. The tool is capable
to assess the COVID-19 risk based on the underlying model that is in turn, a function of various parameters obtained through a questionnaire survey (see Fig. 1).

### 2.1. Software architecture

Covira is a real-time COVID-19 risk assessment tool developed in the Client–Server architecture model. It is developed in the Model-View-Controller (MVC) software design pattern. MVC is a well-established model that has been in development for a long time. This has been the choice of many developers in web-based software development [18]. The MVC-based framework in PHP-Laravel is used as it has been found superior to other frameworks [19]. It separates the application data and business logic (model) from the presentation (view). Model is the central component of this type of pattern which manages the data and rules of the application. It performs data validations as well as process, store, and retrieve it. 'View' is the representation of any information in the application. It deals with presenting the data to the end-user in the form of text, a chart, diagram, or table. The controller is the mediator between the models and views. It deals with the user’s request for any resource from the server.

The software is divided into three major modules: personal risk assessment, regional risk assessment, and result visualization. The former one is solely computed within the web environment of the software based on the user entered questionnaire survey response whereas in the case of the later, major chunk of the spatial operation occurs in R and the intermediate result is fed into the business logic to get the final risk score. The final step is to present the result to the end-user through a score chart and strong visual geo display along with personalized advice based on the computed risk score.

### 2.2. Software functionalities

Covira allows users to assess their personal risk through an online questionnaire survey available in the public view of the web portal. Responses related to age, gender, current location of the person, occupation, hygienic habit, exposure, current health condition, and symptoms (if any) are recorded. Based on the response, a personal risk score is calculated and a risk card along with the personalized suggestion is displayed. The result can be shared on social media (Facebook) as well.

The users then can voluntarily move ahead with the further survey. Few more questions related to profession, neighborhood density, existing cases, inbound travels, health facilities, and other socio-economic parameters are asked in this phase. Based on the response, a further risk card on the probability of COVID infection, and regional risk of transmission is displayed.

Maps depicting socioeconomic risk, public health risk, food productivity risk, transmission risk, and overall risk are generated in R and are loaded in the web interface for better communication of the risk to the general public. The overall risk right after the peak of the first wave (a) and before covid (b) is depicted in Fig. 2. Apart from the personal risk, which is entirely based on personal data, all other risks are local to the territory of Nepal. However, provided the data, the software tool can be extended to fit any part of the world. The snapshot of the UI is presented in Fig. 3.

### 3. Illustrative examples

For the assessment of personal risk, the responses in the questionnaire are recorded. The ID and weight for a factor and
its corresponding activity, condition, habit, or situation are already seeded into the database. This weight is something that the researchers determine empirically through the Delphi method [9]. The snapshot of the source that uses the weight factor of different health conditions and the calculation for comorbidities factor based on the age and other coefficients are depicted in Figs. 4 and 5.

Based on the responses captured, different types of risks and weighting factors are calculated following the governing equation which is obtained as a result of the theoretical research.

After the calculation of all different types of risks, the final risk is calculated and the level of risk is determined on the basis of which, risk card is generated and is communicated to the user as a personalized message. Fig. 6 illustrates the personal and regional risk communication card as displayed after the assessment is completed in the Covira tool.

4. Impact

The application has been successful in drawing the attention of the researchers, academicians, social workers, and the general public since the first release of the software on the public domain https://Covira.info/ on the 21st of July, 2020. There are more than 17,000 views on the application portal, around 1000 natural reach on the Facebook page each time we have some posts. There are more than 700 risk assessment entries in the application among which 621 are from Nepal and the remaining are spread all over the world. The conceptual framework and theoretical backing of this application have already been peer-reviewed and published in Nature publication’s scientific reports journal [9,9].

The government of Nepal has imposed the nationwide lockdown during the first wave of COVID-19 but during the second wave, it has been implemented based on the regions primarily depending upon the number of active and new COVID cases. This work urged the same approach which was published in between two waves. The direct impact is still unknown however, the presented model might have impacted the decision-making process. The launch of this tool was well appreciated and was covered in many national printed and online papers. As the tool was first peer-reviewed and launched by the Nepal Engineers Association, it is believed to reach many government officials with decision-making capacity.

People mentioned that they used this application to assess the risk of the destination city before they started their travel. A good number of people mentioned that they assessed the personal risk and they liked the personalized suggestion displayed based on the risk score they had. Based on the requests from the users, the tool is being enhanced by integrating interactive maps on the geo-visualization and towards the development of the application program interface (API) for ease of access. Nonetheless, Covira is developed following a modular, scalable, and flexible approach that works smoothly with a minor configurational change to fit any mathematical and empirical model. So, it can be used by the researchers as an assessment and visualization tool in order to validate their model and proof of concept.

![Fig. 5. Calculation for comorbidities factor based on the age and other coefficients (covira/app/Base/Helpers/RiskCalculationHelper.php).](image5)

![Fig. 6. Risk communication card as displayed after the assessment is completed in the Covira tool.](image6)
5. Conclusions

To conclude, Covira is a free and open-source web application developed using PHP (Laravel framework), R, and PostgreSQL database with geo-visualization of the COVID-19 risk in the form of risk charts calculated over responses received in the questionnaire. It further calculates the regional risk and disseminates the risk information in the form of maps.

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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