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Priscilla Rogers is a Research Staff Member at IBM Research - Australia, and the manager of the Laboratory's Healthcare Research team. In this role, she is responsible for driving the research agenda in healthcare, and is passionate about data-driven healthcare and pioneering technologies for transformative plays in the sector. Priscilla studied Mechanical Engineering at Monash University, and holds a PhD in acoustic microfluidics for lab-on-a-chip device applications, also from Monash.

Spatio-temporal visualisation of disease incidence and respective intervention strategies

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SUMMARY

The ability to effectively collect and leverage information offers rich new insights, which can greatly inform decision making within healthcare practice and health systems. In this study, we show how information can be collected, analysed and presented in new ways to inform key decision makers in understanding the prevalence of disease and the response to interventions. We demonstrate this for malaria, using data sources from Kenya, where malaria is one of the three biggest causes of mortality for children under the age of 5 in the sub-Saharan continent of Africa[1].

INTRODUCTION

Health research and "big data" have the potential to provide powerful new insights. Frameworks, which have the ability to collect and store data in a secure manner, organise and prepare the data, conduct advanced analytics, and display the data in a visually compelling way offer many possibilities to improve healthcare planning and delivery. A pressing problem in developing nations is childhood mortality. Despite the availability of effective intervention strategies, pneumonia, diarrhoeal disease and malaria remain the top three causes of mortality for children <5 years in Africa[1]. In this region there remains a lack of accurate disease incidence and healthcare data with a spatiotemporal resolution appropriate for effective intervention planning and implementation. In this study, we developed a web-based visualisation portal using select and simulated data sources that would allow relevant bodies, such as public health officials, to visualise the disease burden of a particular disease and the potential impact of available and relevant interventions.

DESCRIPTION

The Cognitive Healthcare and Health Systems Hub is a framework that provisions the ability to collect, store and analyse data from many data providers in a secure manner. The visualisation portal allows relevant bodies to obtain and visualise tailored insights into data within the Hub. This includes a portal to visualise the disease burden of a particular disease and the potential impact of available and relevant interventions. The portal employs a geospatial 3D environment in which to visualise data, enabling the user to view information from a sub-county/town/house level through to a country wide overview. By further augmenting the disease model data with information representing other entities, such as points of interest (i.e. healthcare clinics, pharmacies etc) we can obtain a deeper insight into the disease and appropriate resources available to the different regions.

At its most basic, the disease model data is visualised by utilising a combination of D3[2] and Cesium[3]. The D3 framework is used to process the visualisation data and transform it into a form ready for presentation. The Cesium framework is used to present the visualisation data within a geospatial 3D environment, for example displaying sub-county boundary lines, sub-county names, points of interest etc., right through to rendering the level of red shading within each sub-county region to represent the estimated incidence of disease. Enhanced user functionality is provided by the framework, allowing the user to both navigate the 3D environment and clearly see how the disease burden changes with space and time.

The Spatiotemporal Epidemiological Modeler (STEM), an open source tool to simulate models of disease, was used to generate data for an epidemic malaria outbreak and associated public health interventions in Kenya[4]. STEM contains a malaria disease model to simulate disease transmission by region using environmental and earth science data sources, including elevation, temperature, precipitation, and vegetation coverage[5,6].

To model malaria in Kenya and integrate the intervention scenarios, we made several changes to the included models and data in STEM. First, we replaced the default Kenya data with higher resolution political and earth science data sources, enabling simulations at sub-county resolution. Next we modified the program to modulate disease model parameters by region. This allows us to target interventions for specific regions. For the "distribute bed nets" intervention, the malaria model's biting rate was modified; for "spray insecticide", we constrain the mosquito population. To feed simulation data directly to the visualisation portal, we also implemented a JSON data logger in STEM. Model parameters for the baseline and intervention scenarios were derived from literature.

The portal enables the user to select which scenario output to visualise. Such visualisation allows intuitive access to information essential for those interested in understanding transmission dynamics or planning disease control strategies. Future versions could also link directly to the simulation engine, allowing scientists to modify rate parameters real time to the simulation and actively test alternate hypotheses. Such comparisons will greatly inform public health policy-makers.

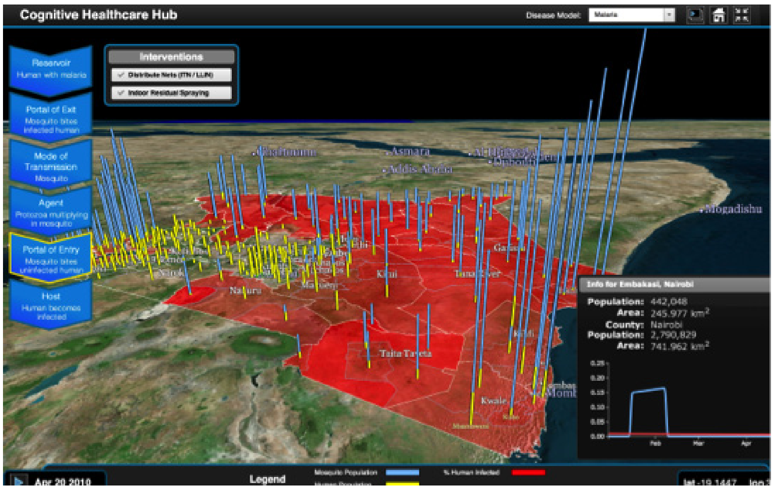

FIGURE 1. Visualisation portal displays simulated disease incidence in Kenya (no interventions are applied).

CONCLUSION

In this study, we simulate disease incidence data for various scenarios using a mathematical model for analysing and visualising the infectious disease spread in human populations over time and over geographies. We have shown how leveraging information can be used to inform users on the prevalence of disease and the ways in which the diseases are best treated and prevented.

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