Intelligent Health Care Service Delivery System

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Abstract

The demographic make-up of areas for Elderly and Maternity population, their corresponding required health facilities and the current resources in health facilities can enable better procurement and allocation of required resources. The future demand forecasting of the resources to cater unique health needs of each population group would lead to better quality and timely health care service.

1. Introduction

Increasing expenditures and demand growth for health facilities in developed countries leads to a necessary exploration and possibility of designing efficient health care systems.(Ahmadi-Javid et al., 2017)
The design includes optimal acquisition and allotment of resources for an area. This foremost requires an accurate measure of resource necessity in an area.(Wang, 2012)
One of the challenges of health care system in US is unequal access to health due to wealth and racial differences. This leads to poor health quality measures, many humans without health access and leaves US behind other developed countries despite spending more on health than any other nation.(Dickman et al., 2017) (Wang, 2012)
The proposed system is an intelligent system based on population health care need rather than wealth and racial standing of an area.
The system would predict requirement of resources both staff or equipment resource to be acquired in total and allocated to specific health care centers. It would also predict future demand as per increasing/decreasing needs of an area leading to an cost effective optimal policy in the end.

2. The Data

Zip Code, a geographic unit of analysis lacks standardization and leads to problems in analysis for researchers.(Grubesic & Matisziw, 2006) The datasets used in this study follow Zip code tabulation areas ZCTAs level of analysis.

Dataset 1.3.1 (Ntroduction, n.d.), namely *Facilities* comprises of ID, Area Zip code , Current Capacity of; Primary, Secondary, and Tertiary service types for all health facility centers.
These service types are categorized in the following way,

1. Primary Service offers
    a. Basic care
    b. Maternity
    c. Childcare
    d. Prevention Treatment.
2. Secondary Service offers
    a. Specialized care
    b. Respiratory
    c. Acute/Serious illnesses.
3. Tertiary Service offers
    a. Advanced medical investigation
    b. Cancer treatment
    c. Neuro Disease
    d. Cardiac

"*Facility ID*" uniquely identifies each record. "*Facility Zip Code"* is assumed to have correspondence with ZCTAs of the Washington state. "*Facility Primary Capacity"* is a numeric variable depicting catering capacity of the facility in Primary service. The other two service capacity variables are similar.
Two datasets of ZCTA geographic level were extracted from source website US Census Bureau for the year 2018. The useful information in the datasets is Maternity and Age estimated percentage of the total population.

2.1. Data Pre-Processing

Necessary transformation and data integration is needed before making any calculations.
Data is loaded, transformed and integrated using "pandas" library in Python.
Columns of Object and String data type to be used in calculations, are converted to float data type.
Intersection of datasets over ZCTA columns gives required information in one dataset of shape (5, 403).
For details please refer to the code in GitHub project.

3. Current Population Counts

Calculations for current population count for elderly and maternity population category.

3.1 Current Elderly Population Count

Each ZCTA level record has percentage column for elderly(65-74) population. Total population is also given thus current elderly population is calculated as

Population of Area-ZCTA xxxxx = pop
Percentage of Area-ZCTA Elderly = perc
Current Elderly Population of Area-ZCTA xxxxx = pop*perc
For code, please refer to GitHub code (Hamza, Intelligent-Health-Care-Service-Delivery, 2020)

3.2 Current Maternity Population Count

Each ZCTA level record has percentage column for female population. The maternity dataset has survey population column "*Estimate!!Total*" out of which a some number of women gave birth in the past 12 months in column "*Estimate!!Total!!Women who had a birth in the past 12 months*" which is used to get percentage of maternity population. The total female population and percentage of maternity population is used to calculate current maternity population.
For code, please refer to GitHub code. (Hamza, Intelligent-Health-Care-Service-Delivery, 2020)

3.3 Other datasets and their possible use

ZCTA level information is must to comply with the already given dataset 1.3.1 (Ntroduction, n.d.).
The National Center for Health Statistics (NCHS) offers many publicly available relevant datasets which might be adjusted to be used in the proposed service delivery system for optimization of current population count.
Optimization of procurement and allocation of emergency department services can lead to better fulfilling the needs of elder population. According to a research study in 2020 during the period 2014-17 ,20% of the total emergency department visits were made by 60-69 age group and this increases with increasing age. (Ashman et al., 2020)
Maternal care services' resource needs can be identified by studying statistical difference in number of visits to different service providers.(Uddin et al., 2014)
A novel approach for estimating population would be to use cutting edge deep learning techniques. Two research publications shows the possibility of accurately estimating population using deep learning with satellite images.(Robinson et al., 2017) (Sutton et al., 2001)

4. Future Population Counts

The data used is of the year 2018. There is more data available for the previous years at US Census Bureau. This historic data can be used to find increasing/decreasing trends in Maternity percentage, Elderly Percentage and Total Population Percentage on a ZCTA level.

4.1 Other datasets and their possible use for Future population estimation.

The effect of job investment on future population can be studied or predicted using the historic data provided by Immigration Policy Institute MPI which offers several publications as well as factsheets to study immigration trends.

5. Resources demand forecasting for each Service Category

A study suggests modelling methods for estimating HR requirements based on assumed empirical estimates of time and type and number of health workers required.(Daviaud & Chopra, 2008)
The study is data and its underlying assumptions and a study suggests that its dangerous to become overly confident in data. (Tetlock & Gardner, 2015)
It is therefore necessary to model a system that accounts for adaptive nature catering to the rapid-changing needs in healthcare.
It is very hard to select a single model but rather than emphasizing on model we may rather start with any , say regression, LSTM or any predictive analytics model with careful and detailed attention to data quality and features.
Facility centers need to cater a specific percentage of the total estimated Maternity or Elderly population in an area.
A factor(feature) can be calculated for each facility type based on population and historic visit. This factor can be treated as a weight based on which resources are allocated. This factor being based on historic visits and population would thus adapt over time.
Let us assume the following record:
Area : 1
Facility : 1
Facility Primary Capicity: 200
Facility Secondary Capacity: 44200
Facility Tertiary Capacity: 0
Area Population: 29174
Maternity Population within Area: 1979
Elderly Population within Area: 1429
It is assumed that more than half of the population would need health facility services. The whole population would not need medical care at once.

Say 70% of Maternity population , 1385 women would need to visit at least once in 15 days including weekends. Thus, the facility needs at least 92 Primary resources

available per day just for the Maternity population. This number would adapt over time based on daily Maternity visits recorded by the facility.

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