PHBS 北京大学汇丰商学院

The doctor-patient behavior and medical resource allocation of Internet medical platform

廖家瑞 (Jiarui Liao) 1801212884
刘德明 (Deming Liu) 1801212889
曹阳 (Yang Cao) 1801212825
王如思 (Rusi Wang) 1801212938
常鑫磊 (Xinlei Chang) 1801212779

2020-01-13

Contents

Project Introduction

- China has made remarkable achievements in the development of medical and health services, but still faces some challenges, such as information asymmetry between doctors and patients, and uneven distribution of medical resources between regions, urban and rural areas.
- These problems lead to the contradiction between doctors and patients as well as the "difficulty and high cost" of high-quality hospitals.

Project Introduction

- The convergence of Internet technology and medicine has brought about the emergence of Internet medical platforms, including medical service retrieval, medical knowledge sharing (DXY.com), online consultation and appointment website (haodf.com).
- Internet medical treatment will help patients to search for information, and also facilitate the reorganization and sharing of doctors' knowledge and skills and other resources in time and space. And this is conducive to the rational allocation of high-quality medical resources.

Project Introduction

- Based on the doctor-patient data of haodf.com, this project focuses on the improvement effect of the Internet on the imbalance of medical resources by studying **the geographical distribution of patients and their willingness to consult.**

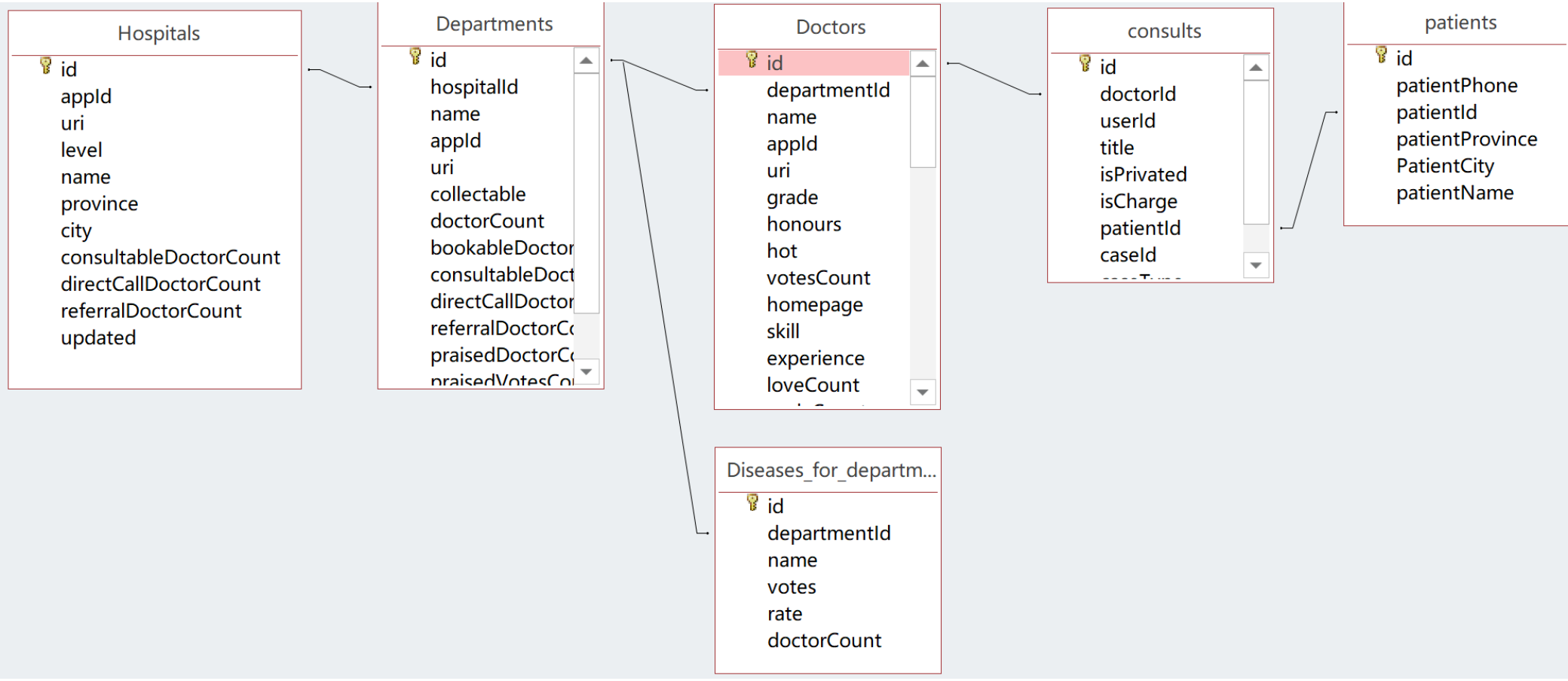
1. **Visualization of geographical distribution of medical interaction**

2. **Factors influencing the difference in medical interaction decision making (Regional factors, Willingness to consult)**

Contents

Data Overview

- On the website of Haodf, we collected all relevant data from most departments of all hospitals in some regions (Shanghai, Anhui and Gansu were sampled accordingly)
- Data mainly includes information of hospitals, doctors, patients.



Data Overview– Hospital Information

- Location, departments, level…

Data Overview– Hospital Information

- Location, departments, level…

Data Overview– Doctor Information

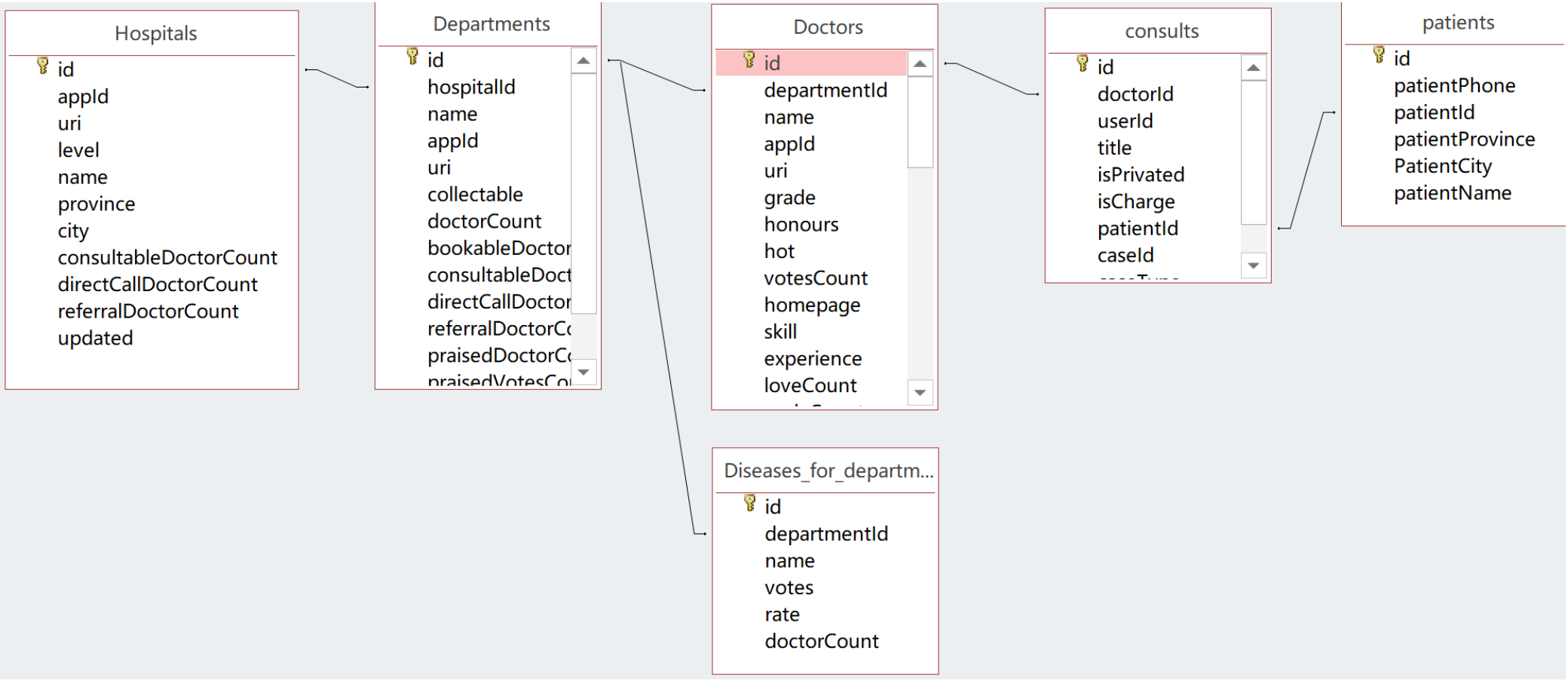
- Location, title of a technical post, department, skill…

Data Overview– Patient Information

- Location, consulting text, related diseases, number of consulting, time of consulting…

Data Overview——Database

- We split previous data into several tables based on 2NF (considering the difficulty of query, we did not implement 3NF)



Data Preprocessing

- Messy code
- Redundancy

```
select patients.patientcity,count(1) as counts from
(SELECT departments.id,
        departments.name, doctors.id,
        hospitals.name,
        consults.patientid,
        patients.patientprovince,
        patients.patientcity
FROM (((Departments
        INNER JOIN hospitals
        ON departments.hospitalid=hospitals.id)
           INNER JOIN doctors
           ON departments.id=doctors.departmentid)
              INNER JOIN consults
              ON doctors.id=consults.doctorid)
                 INNER JOIN patients
                 ON consults.patientid=patients.patientid
WHERE hospitals.province='上海')group by patients.patientcity
```

patientcity	counts
	408024
--------	1
&#65533;ϳ&#655	1
&#65533;&#65533;&#63	4
&#65533;&#65533;&#65	1
&#65533;&#65533;&#80	1
&#65533;ζ&#65533;	1
?	18
??	300
???	39
□ □□ □□	1
14	1
2	6
231	1
5	1
6	2
ü?	42
wuxi	1
阿坝	222
阿克苏	564
阿克苏地区	1
阿拉善盟	146
阿勒泰	180
阿勒泰地区	4
阿里	22
安康	825

Data Preprocessing

patientcity	counts
	408024
--------	1
&#65533;ϳ&#655	1
&#65533;&#65533;&#63	4
&#65533;&#65533;&#65	1
&#65533;&#65533;&#80	1
&#65533;ζ&#65533;	1
?	18
??	300
???	39
□ □□ □□	1
14	1
2	6
231	1
5	1
6	2
ü?	42
wuxi	1
阿坝	222
阿克苏	564
阿克苏地区	1
阿拉善盟	146
阿勒泰	180
阿勒泰地区	4
阿里	22
安康	825

patientcity	counts
阿坝	222
阿克苏	565
阿拉善盟	146
阿勒泰	184
阿里	22
安康	825
安庆	5522
安庆市	27
安顺	476
安阳	1711
鞍山	1447
鞍山市	2
巴东	1
巴南	8
巴彦淖尔	855
巴音郭楞	631
巴中	722
白城	630
白沙	1
白山	627
白银	583
白云	2
百色	342
蚌埠	3826
包头	1708

Contents

The role of data visualization in this study

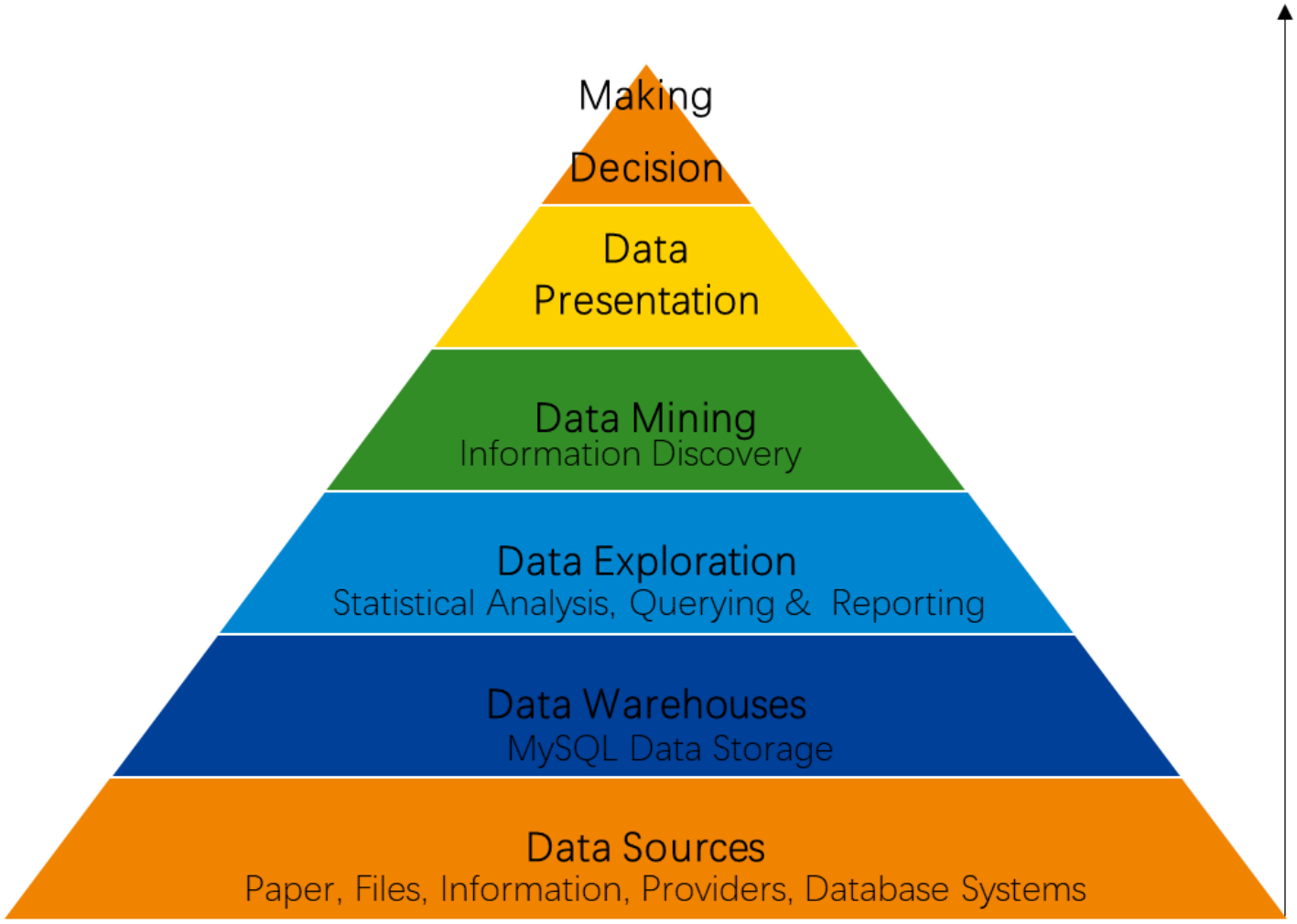
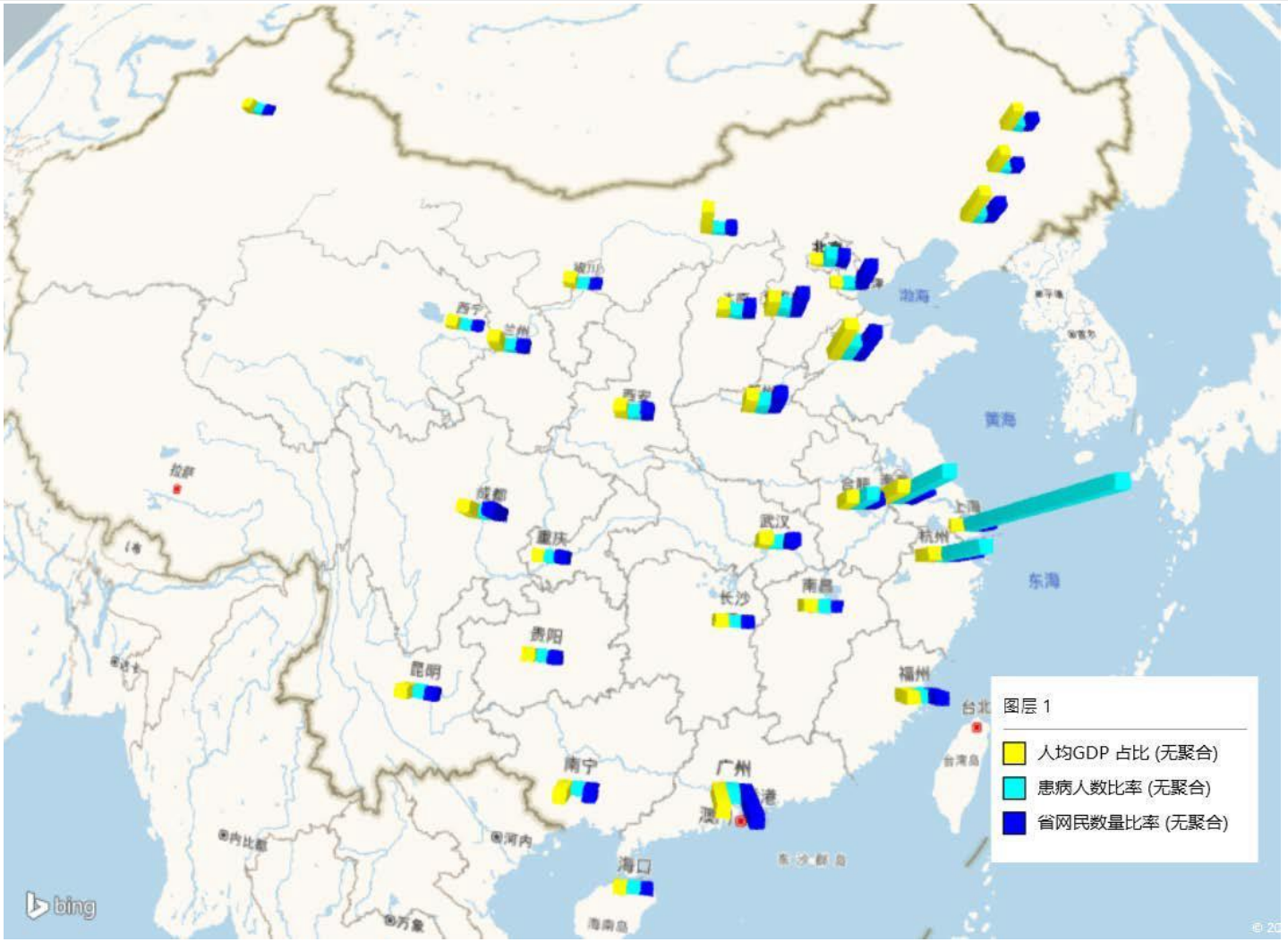


tableau PARTNER

pyecharts

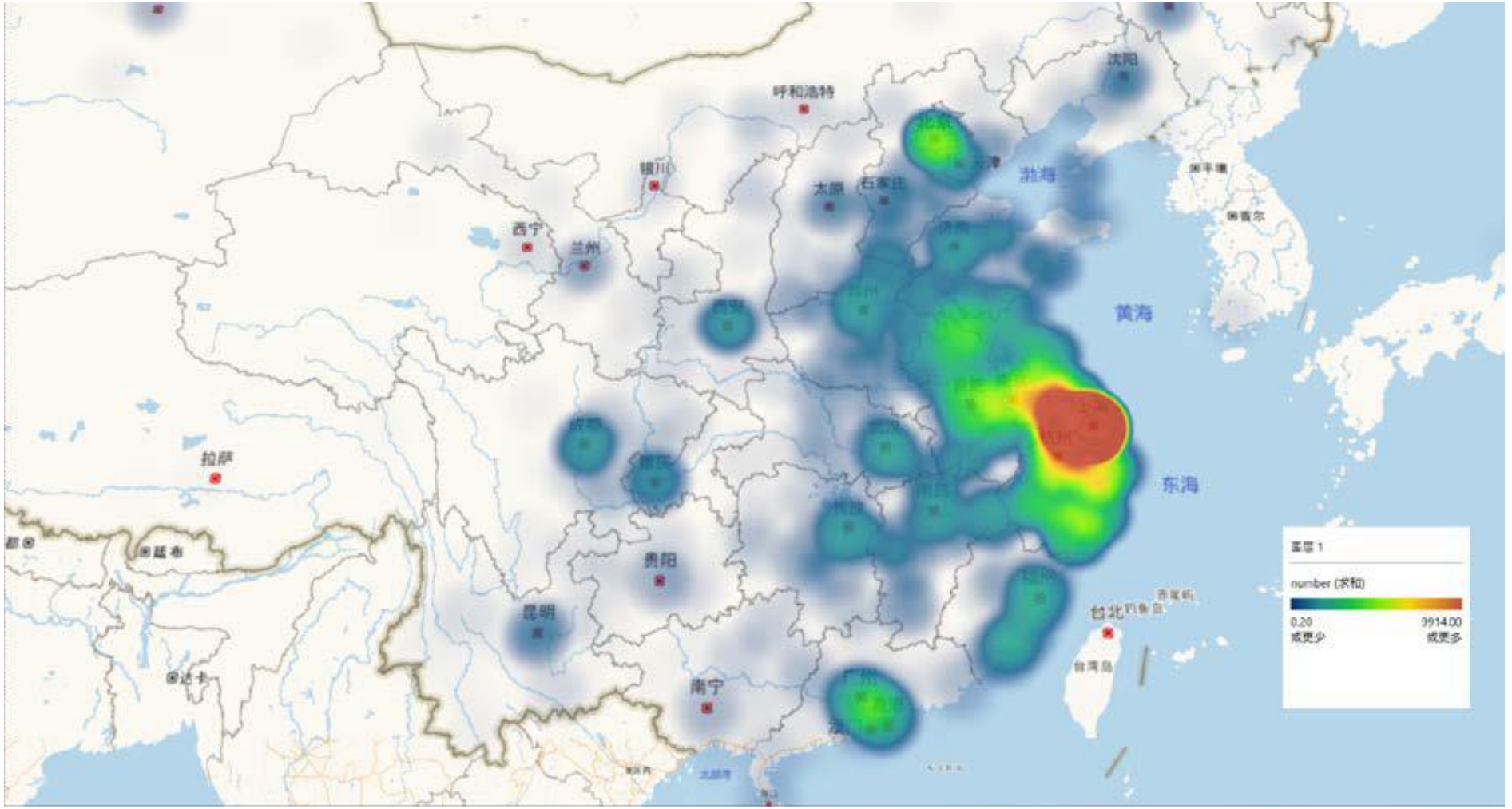
Python ♥ Echarts = pyecharts

Cluster information graph by Power Map



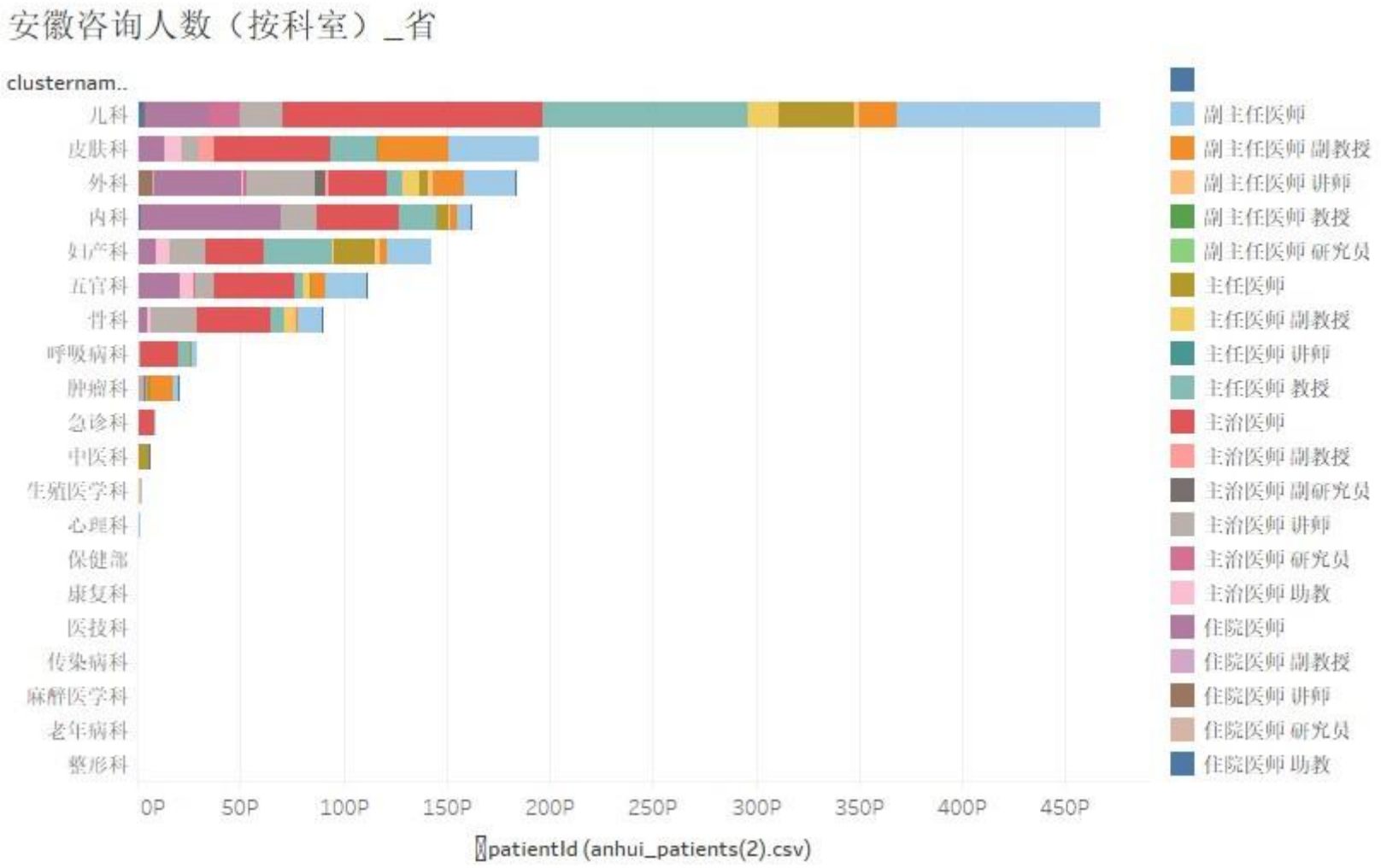
Combine the per capita GDP, the number of patients, and the number of netizens, and then normalize them. The purpose is to intuitively test our hypothesis that the number of consultants is related to GDP and the number of Internet users

Thermal map of online consult to Shanghai



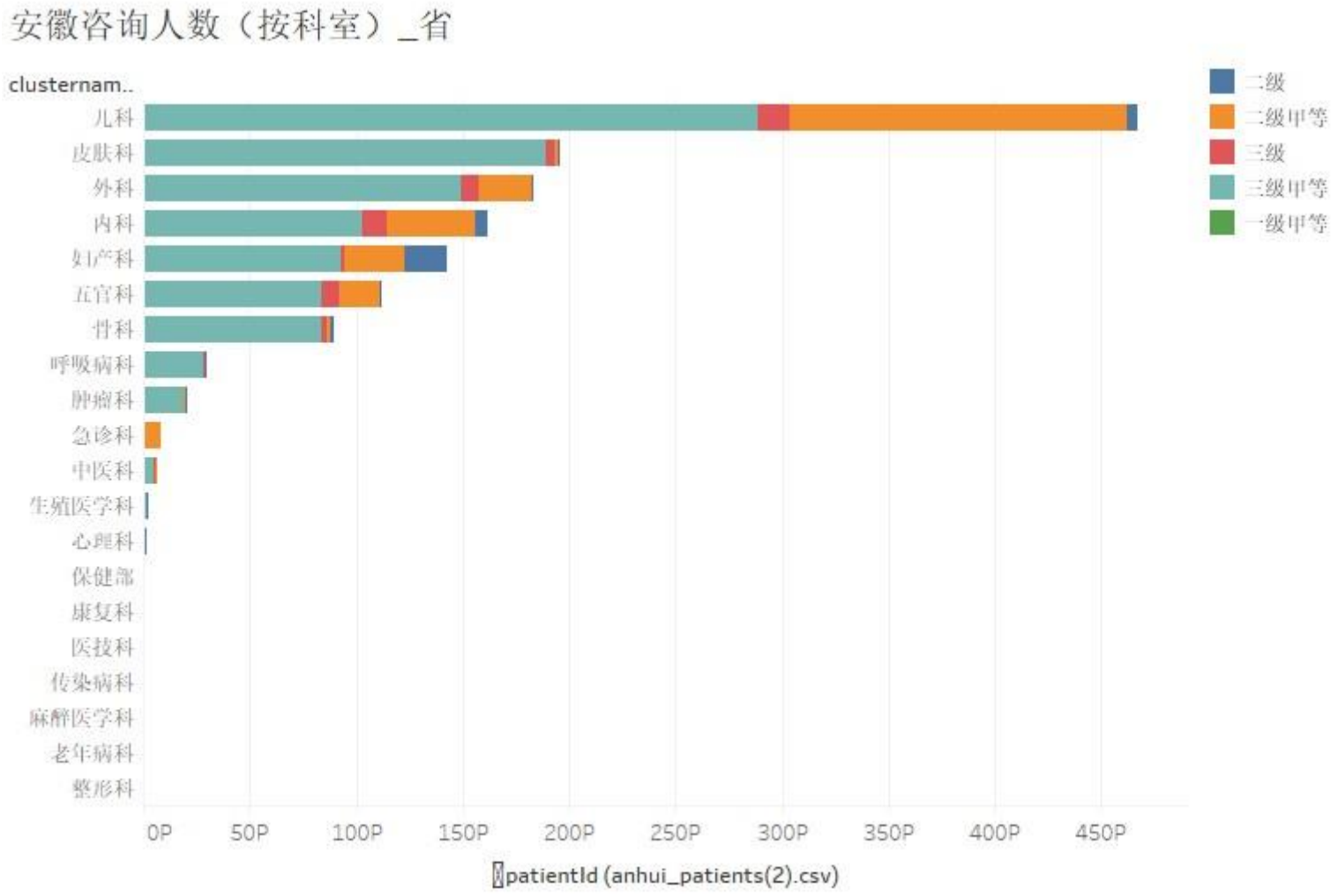
In order to better show the impact of regional differences, we have drawn a heat map for consulting Shanghai in cities across the country.

Doctor level statistics of Anhui in consult list



Chief, Associate Chief, Attending Doctor are the doctors most frequently consulted

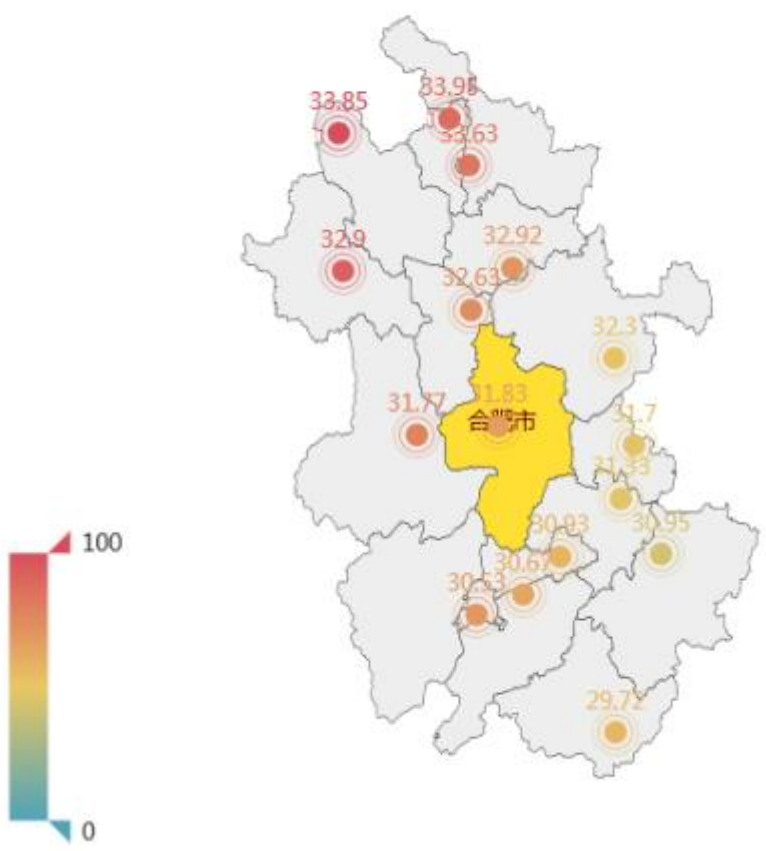
Hospital level statistics of Anhui in consult list



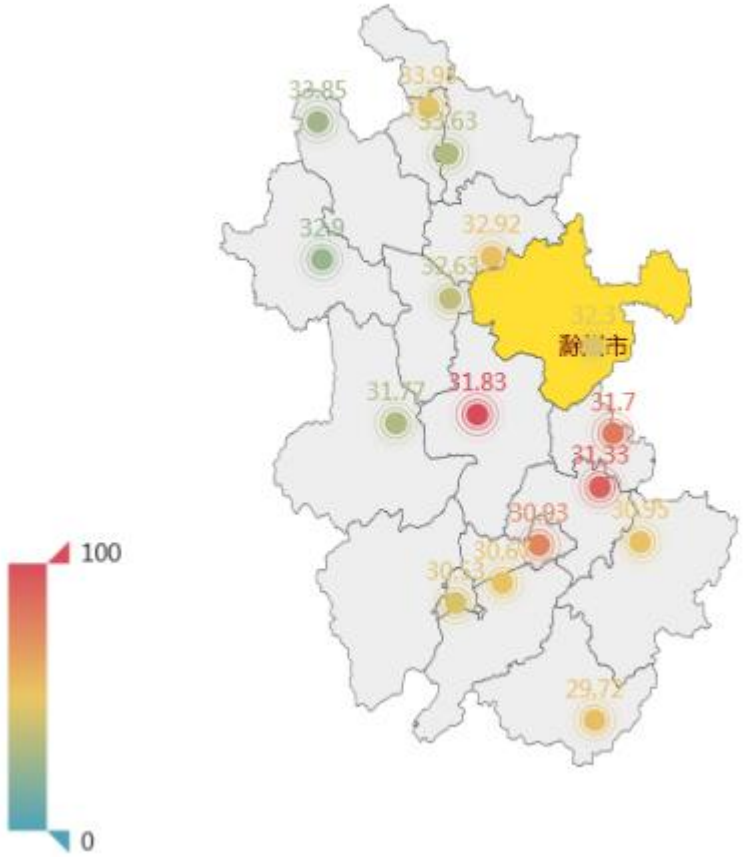
Horizontal comparison: The majority of patients in the same department choose: Grade-A Tertiary Hospital.

The region feature of Anhui Province

Distance between Shanghai and cities in Anhui Province



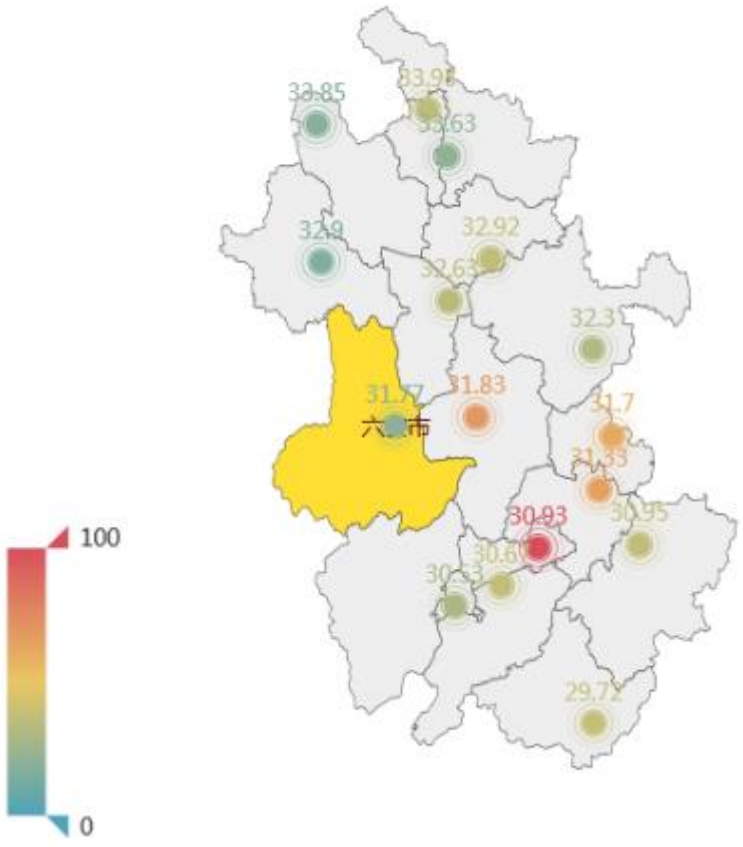
Medical level score of cities in Anhui Province



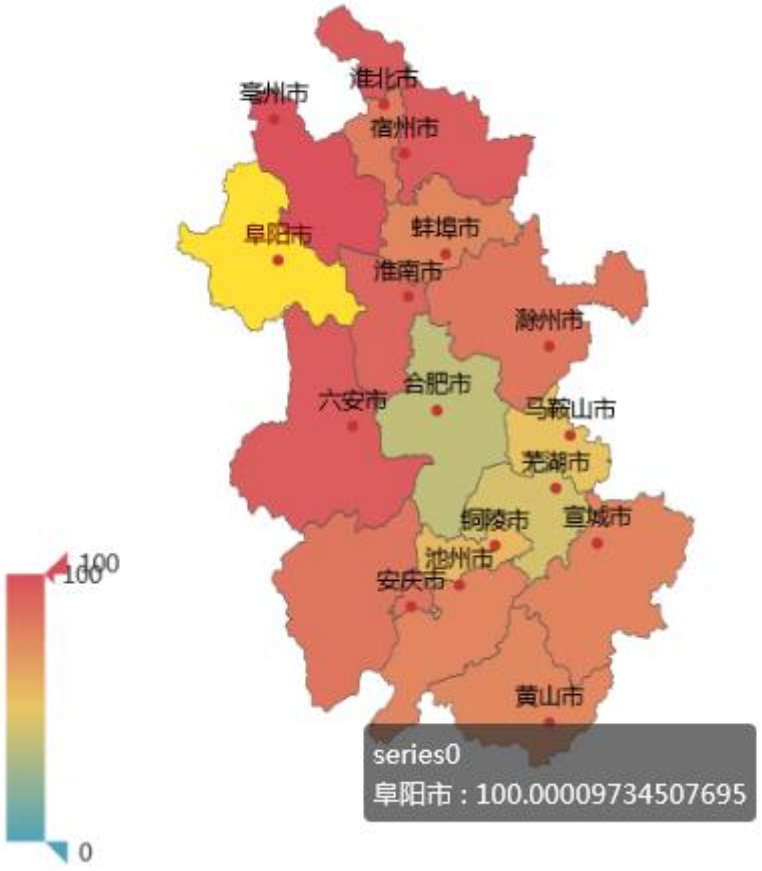
Through data processing and data visualization, we can have a unified understanding of the medical level and GDP of each city in Anhui Province.

The medical level gap between Shanghai and Anhui

GDP per capita of cities in Anhui Province



Difference of medical level between Shanghai and cities in Anhui



Those information could help us in the model construction.

Contents

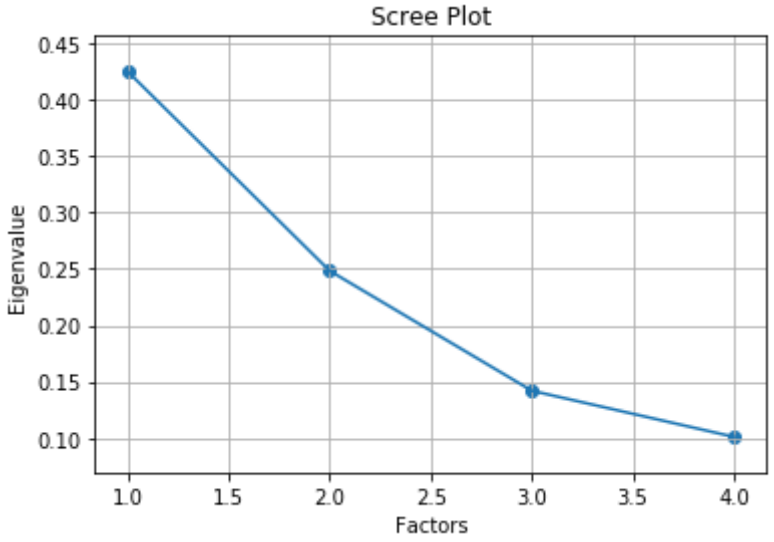
Data Modeling

- Construct Medical level indicator using PCA
- Logistic regression

Evaluation indicators of Medical level

- Method：Principal Component Analysis
- Tool：Python
- Features(indicators)：
  - The elderly dependency ratio
  - Number of medical institutions
  - Number of hospitals
  - Number of medical beds per 10000 people
  - Number of medical personnel per 10000 people
  - Number of practicing physician per 10000 people
  - Average hospitalization day
  - GDP

Evaluation indicators of Medical level



Feature	Components_1	Components_2	Components_3
elderly dependency ratio	-0.421	-0.129	0.799
Number of medical institutions	0.520	0.582	0.499
Number of hospitals	0.349	0.758	-0.276
Number of medical beds	0.861	-0.405	0.054
Number of medical personnel	0.939	-0.207	0.125
Number of practicing physician	0.936	-0.238	0.157
Average hospitalization day	0.750	-0.426	-0.238
GDP	0.787	0.559	0.062

Three components can explain the 81.5% of the total variance

- The first component reflects the economic and medical resource level
- The second principal component reflects the degree of medical competition
- The third principal component reflects population and aging factors

Evaluation indicators of Medical level

Construct the Medical level using three components, the weight of each components can be calculated by following formula

$$Weight_i = \frac{Var(x_i)}{\sum_{i=1}^{3} Var(x_i)} = \frac{\lambda_i}{\sum_{i=1}^{3} \lambda_i}$$

	City	elderly dependency ratio	Number of medical institutions	Number of hospitals	Number of medical beds	Number of medical personnel	Number of practicing physician	Average hospitalization day	GDP	Medical level
0	Hefei	15.83	2217	146	56	61	23	11	5660.27	13276.51751
1	Huaibei	13.51	718	73	55	50	19	10	760.39	6328.77547
2	Haozhou	14.60	1705	55	33	30	11	7	942.61	3576.32820
3	Suzhou	17.24	1880	73	35	39	15	8	1235.83	4248.65928
4	Bangfu	16.74	1413	83	54	53	19	10	1253.05	6995.21678
5	Fuyang	16.78	2644	97	40	38	14	8	1267.45	3242.62066
6	Huainan	17.39	1211	67	40	41	15	11	901.08	4861.05483
7	Chuzhou	15.85	1655	61	40	39	15	9	1305.70	6026.79145
8	Liuan	15.45	2701	37	43	44	19	8	1016.49	4209.93965
9	Maanshan	20.35	1005	55	37	50	19	9	1365.30	10923.09195
10	Wuhu	16.40	1436	78	51	54	21	9	2457.32	12188.90280
11	Xuancheng	19.02	1330	40	43	49	19	8	971.46	6864.70094
12	Tongling	17.43	306	18	38	37	14	14	911.60	10218.18171
13	Chizhou	15.54	982	32	44	49	20	9	544.74	6887.73138
14	Anqing	16.64	2497	72	43	49	19	9	1417.43	5877.07508
15	Huangshan	20.90	1153	31	49	62	23	10	530.90	7053.73530

Data Modeling

- Construct Medical level indicator using PCA
- Logistic regression

Logistic Regression

- We add the weighted value of each component to form a new variable called Medical_Level It means the comprehensive score of the city's medical level.
- Combine into the patient's data.
- However, every patient now has the same city attributes

地区	到上海的距离（公里）	人均地区生产总值（全市）/元	医疗水平综合得分	与上海医疗水平的差异
合肥市	408.1	67689	13276.51751	5827.21859
淮北市	532.5	35324	6328.77547	12774.96063
亳州市	607.8	17769	3576.3282	15527.4079
宿州市	503.9	20895	4248.65928	14855.07682
蚌埠市	429.7	35542	6995.21678	12108.51932
阜阳市	563.5	15303	3242.62066	15861.11544
淮南市	451.5	33361	4861.05483	14242.68127
滁州市	315.5	30562	6026.79145	13076.94465
六安市	472.4	19211	4209.93965	14893.79645
马鞍山市	286.1	60091	10923.09195	8180.64415
芜湖市	289.6	64039	12188.9028	6914.8333
宣城市	259.3	35726	6864.70094	12239.03516
铜陵市	350.9	97193	10218.18171	8885.55439
池州市	387.0	36267	6887.73138	12216.00472
安庆市	424.6	28808	5877.07508	13226.66102
黄山市	346.1	37306	7053.7353	12050.0008

Logistic Regression

- Therefore, we investigate the other information and invent a new variable called Utility Score.
- It measures the urgency or utility of a patient.
- More words to describe his illness, more phone calls, higher score
- A comprehensive score of Length of Description, Numbers of Phone Calls, Total Time of Consulting.

	patientId	score	city	distance	gdp	medical_level	medical_dif	patientId	prov	doctorId	name	doctorgrade
0	1013185098	8	阜阳	563.5	15303.0	3242.62066	15861.115440000000	1013185098	安徽	21587	杜永强	主任医师 教授
1	1013185098	8	阜阳	563.5	15303.0	3242.62066	15861.115440000000	1013185098	安徽	21587	杜永强	主任医师 教授
2	1013185098	8	阜阳	563.5	15303.0	3242.62066	15861.115440000000	1013185098	安徽	21587	杜永强	主任医师 教授
3	1013185098	8	阜阳	563.5	15303.0	3242.62066	15861.115440000000	1013185098	安徽	21587	杜永强	主任医师 教授
4	1013185098	8	阜阳	563.5	15303.0	3242.62066	15861.115440000000	1013185098	安徽	21587	杜永强	主任医师 教授
5	1013185098	8	阜阳	563.5	15303.0	3242.62066	15861.115440000000	1013185098	安徽	21587	杜永强	主任医师 教授
6	2255034500	5	亳州	607.8	17769.0	3576.3282	15527.4079	2255034500	安徽	16464	江山	副主任医师
7	2255034500	5	亳州	607.8	17769.0	3576.3282	15527.4079	2255034500	安徽	16464	江山	副主任医师
8	2255034500	5	亳州	607.8	17769.0	3576.3282	15527.4079	2255034500	安徽	16464	江山	副主任医师
9	2255034500	5	亳州	607.8	17769.0	3576.3282	15527.4079	2255034500	安徽	16464	江山	副主任医师
10	2255034500	5	亳州	607.8	17769.0	3576.3282	15527.4079	2255034500	安徽	16464	江山	副主任医师
11	2255034500	5	亳州	607.8	17769.0	3576.3282	15527.4079	2255034500	安徽	16464	江山	副主任医师
12	2255034500	5	亳州	607.8	17769.0	3576.3282	15527.4079	2255034500	安徽	16938	项平	主治医师
13	2255034500	5	亳州	607.8	17769.0	3576.3282	15527.4079	2255034500	安徽	16938	项平	主治医师
14	2255034500	5	亳州	607.8	17769.0	3576.3282	15527.4079	2255034500	安徽	16938	项平	主治医师
15	2255034500	5	亳州	607.8	17769.0	3576.3282	15527.4079	2255034500	安徽	16938	项平	主治医师
16	2255034500	5	亳州	607.8	17769.0	3576.3282	15527.4079	2255034500	安徽	16938	项平	主治医师
17	2255034500	5	亳州	607.8	17769.0	3576.3282	15527.4079	2255034500	安徽	16938	项平	主治医师
18	2255034500	5	亳州	607.8	17769.0	3576.3282	15527.4079	2255034500	安徽	24671	王静	主治医师

Logistic Regression

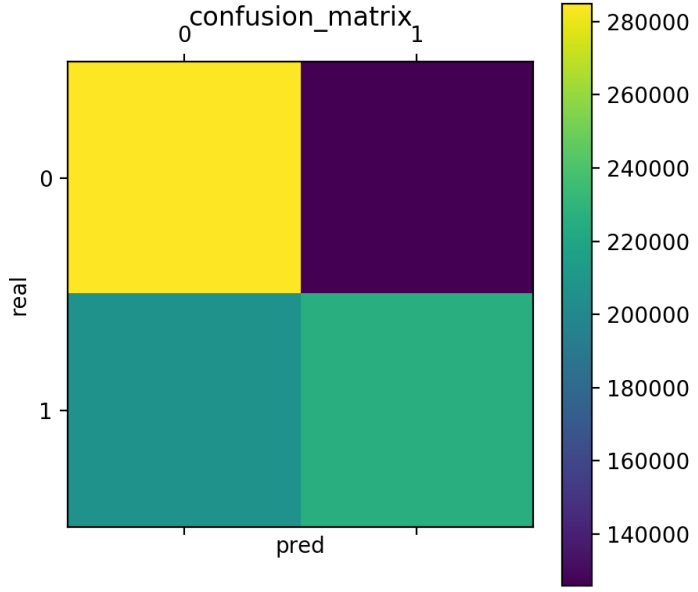
- Then we use Logistic Regression to process our data.
- The result shows that the accuracy, precision and recall are all about 60%, and the coefficients lead to our final results.
- The coefficients: (1) Distance < 0 (2) GDP > 0 (3) Medical Level < 0 (4) Utility Score > 0

```
              precision    recall  f1-score   support

           0       0.58      0.69      0.63    410909
           1       0.64      0.52      0.58    433791

   micro avg       0.61      0.61      0.61    844700
   macro avg       0.61      0.61      0.60    844700
weighted avg       0.61      0.61      0.60    844700

[[-1.29484253e-03  1.76739044e-05 -1.20214732e-04  7.61322211e-02]]
('accuracy_score ', 0.6051177932993962)
('precision_score ', 0.6422969903463941)
('recall_score ', 0.5214884587278206)
[Finished in 33.0s]
```



Contents

Project Summary and Outlook

Whether Internet medical platform is conducive to the allocation of medical resources ?

- **Yes!**
- Taking Shanghai as an example, it can be seen from the visualization results that the consulting patients are all over the country, and people all over the country can enjoy the high-quality medical resources of Shanghai **(especially Grade-A tertiary hospital)** to a certain extent.
- Regional factors and willingness to consult affect patients‘ decision-making. **(1) The closer the distance is, (2) the higher the GDP is, and (3) the poor the medical level is, the more patients choose Shanghai, and (4) the stronger their willingness to consult, the more they choose Shanghai.**

What else can we do in the future ?

DATA →

- The data can be combined with the patient's personal information (family income, duration of illness, age) to provide a more detailed analysis of the factors influencing the patient's decision

MODEL →

- Time variables can be added into the model to study the changes of patients' decision-making in different periods.

References

1. 王霜奉.国外掀起移动医疗“风潮”［J］.上海信息化，2014（3）：84.
2. 曹常义.移动医疗商业路径选择及移动运营商践行经验探讨［J］.移动通信，2014（19）：48-54.
3. 梁怡凡.移动医疗APP的盈利模式探索［J］.中国市场，2015（25）：137-140.
4. 唐超.重构中国互联网医疗模式［J］.中国医院院长，2015（15）：66-72.
5. 张浩辰.互联网与中国医疗模式变革研究［J］.中国物价，2016（4）：62-65.
6. 朱莉华, 曹乾, & 王健. (2009). 居民健康与卫生保健及医疗服务的可及性关系——基于chns 2006年数据的实证研究. 经济研究导刊(13), 211-213.
7. 宋正娜, 陈雯, 张桂香, & 张蕾. (2010). 公共服务设施空间可达性及其度量方法. 地理科学进展(10), 69-76.
8. Murray A T． Site placement uncertainty in location analysis［J］． Computers，Environment＆Urban Systems，2003，27(2) : 205－221．
9. Luo W，Wang F． Measures of spatial accessibility to health care in a GIS environment: synthesis and a case study in the Chicago region［J］． Environment＆Planning B， 2003， 30(6) : 865－884．
10. Tsou K W，Hung Y T，Chang Y L． An accessibility－based integrated measure of relative spatial equity in urban public facilities［J］． Cities， 2005， 22(6) : 424－435．
11. Naess P． Accessibility， activity participation and location of activities: exploring the links between residential location and travel behavior［J］． Urban Studies，2006，43(3) : 627－652．