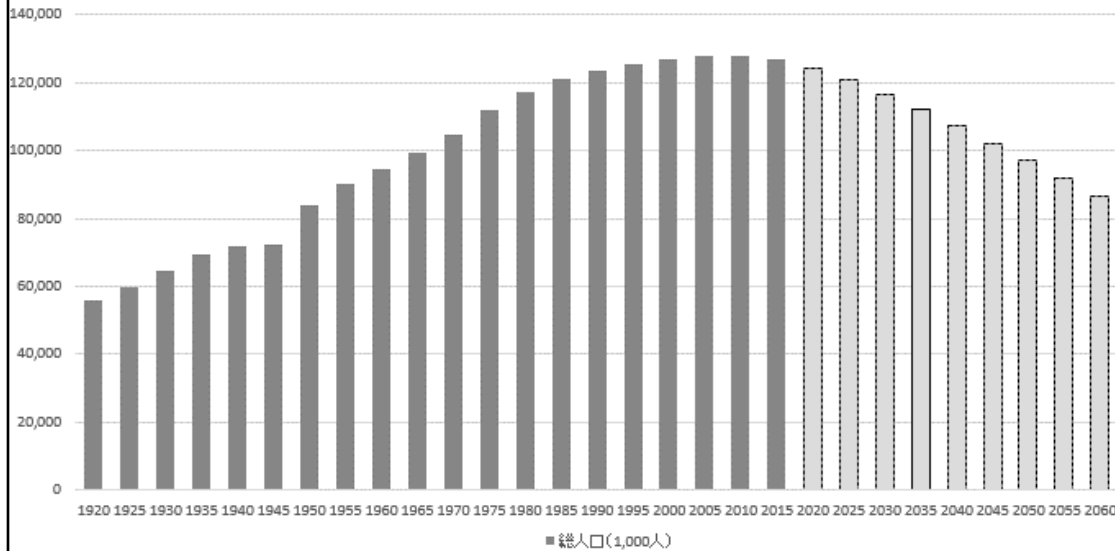# The Analysis of Medical Efficiency and Location Tendency of the Medical Mall in Fukuoka City
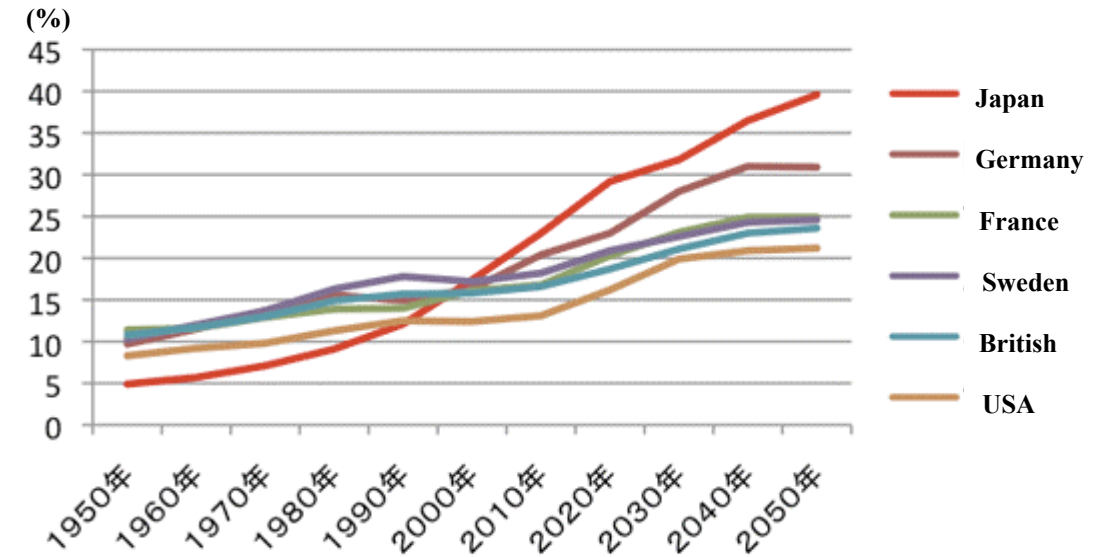
DU Mengge (発表者) , Higuchi Go and ZHAO Shichen

Kyushu University

2020.04.11

Population Reduction

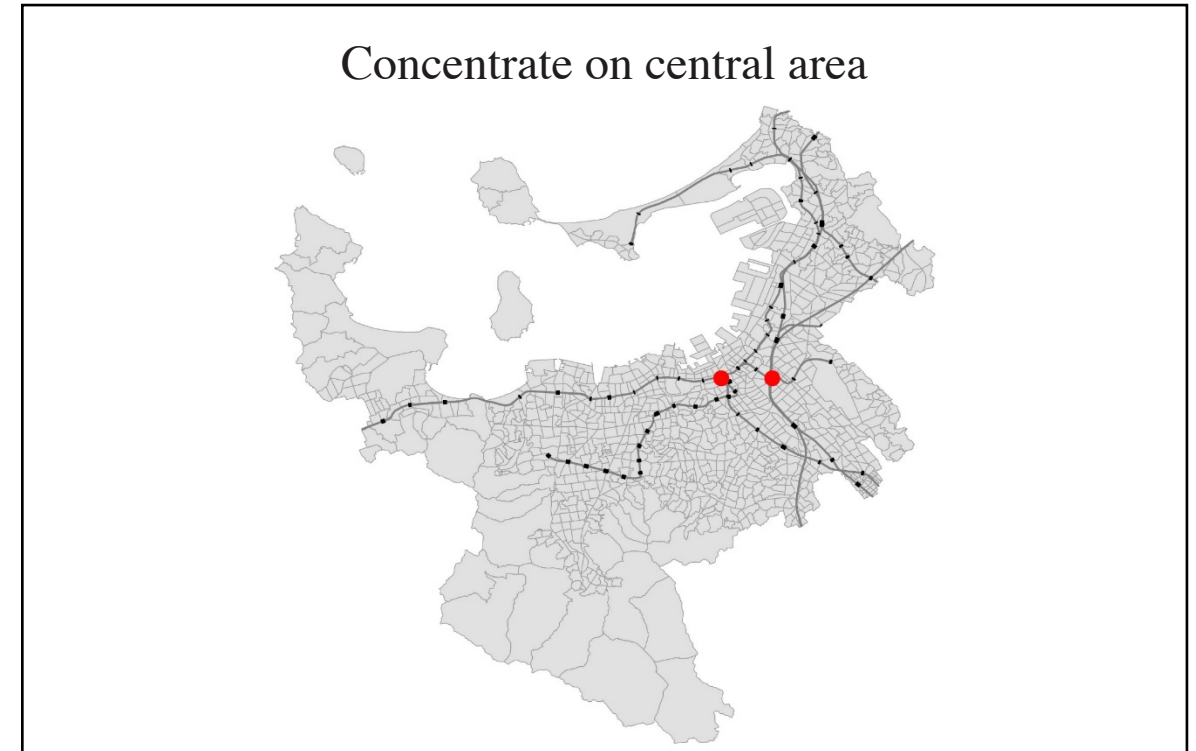The Tendency of Declining Population in Japan
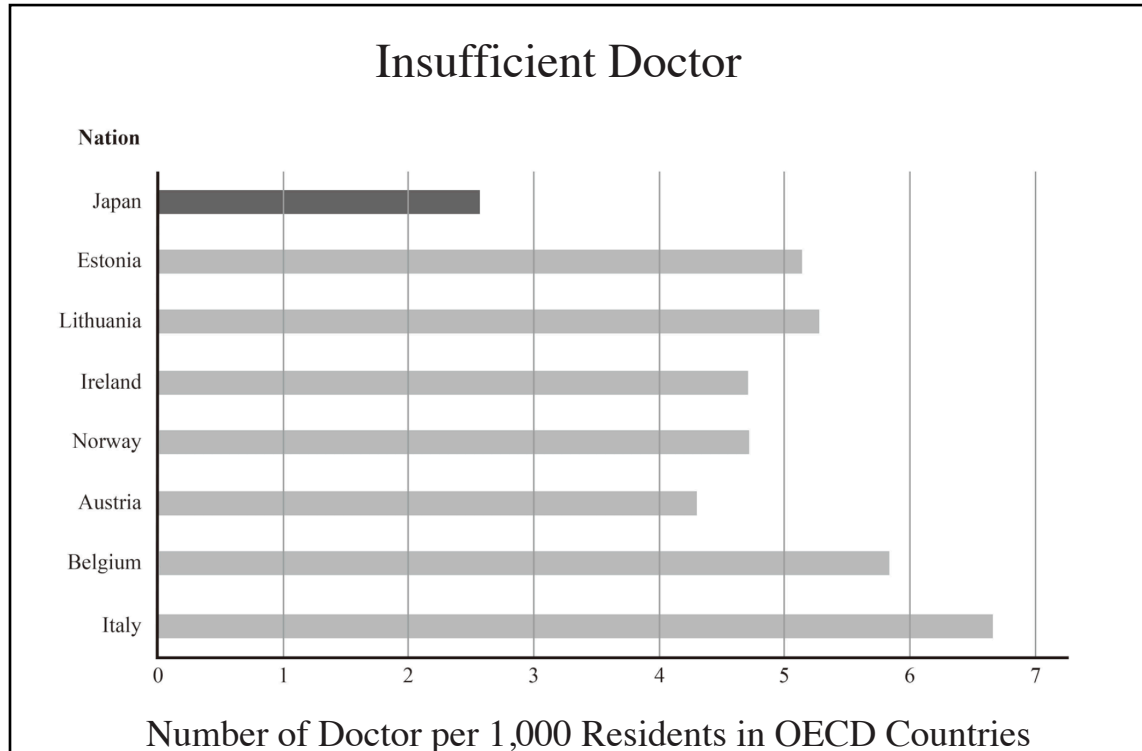
Aging Society

Aging Population in Developed Countries

Decrease of the total population in Japan from 2015, which means the depopulation becomes the new inevitable normal. Meanwhile, the aging population is serious in Japan comparing with other developed countries.

MORE MEDICAL DEMEND

Insufficient Doctor

Nation

Japan	
Estonia	
Lithuania	
Ireland	
Norway	
Austria	
Belgium	
Italy	

0 1 2 3 4 5 6 7

Number of Doctor per 1,000 Residents in OECD Countries

Concentrate on central area

The number of doctors per 1000 people is smaller than the other countries, ranking 62 in the world. Also less than the other OECD (Organization for Economic Co-operation and Development) countries.
Medical facilities are concentrate on the central urban area and many doctors choose to work in the central area.
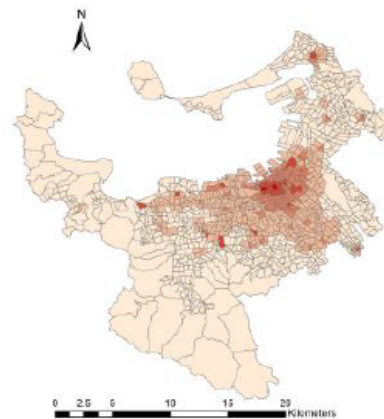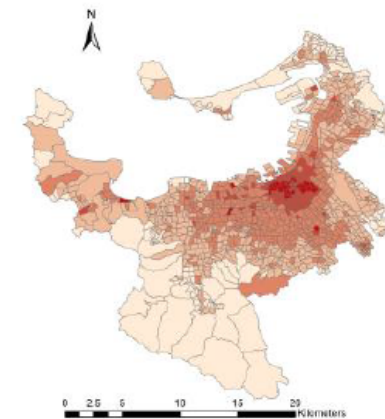
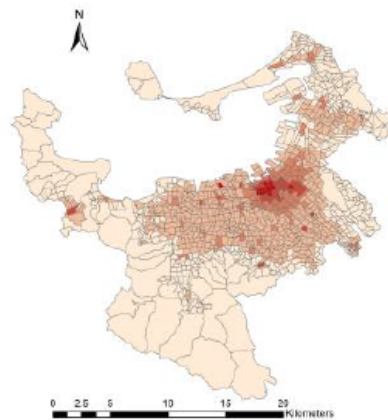INSUFFICIENT MEDICAL SUPPLY

UNBALANCED SUPPLY-DEMAND
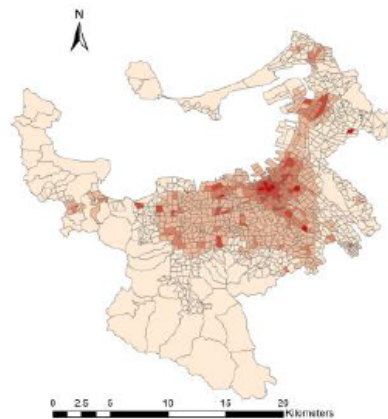
Ophthalmology

Obstetrics and Gynecology

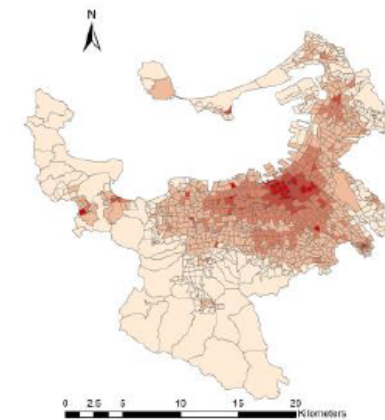Internal Medicine

General Surgery
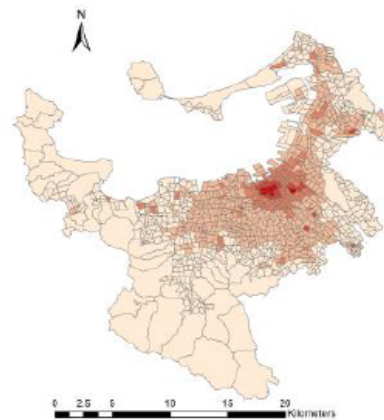
Dermatology

Dentistry

Dark Red
Supply ∨ Demand

Light Red
Demand ∨ Supply

The supply and demand of the medical resources are unbalanced in Fukuoka city.
There is another serious problem that the shortages resources in suburban areas.

A medical mall is a medical building or place gathering with 3 or more medical facilities such as clinics, dental clinics and pharmacies, which contains 2 or more clinics. By integrating the medical resources of different departments and improving the interaction mechanism between doctors and patients, the medical mall can realize the efficient sharing of medical resources and improve the relationship between doctors and patients.
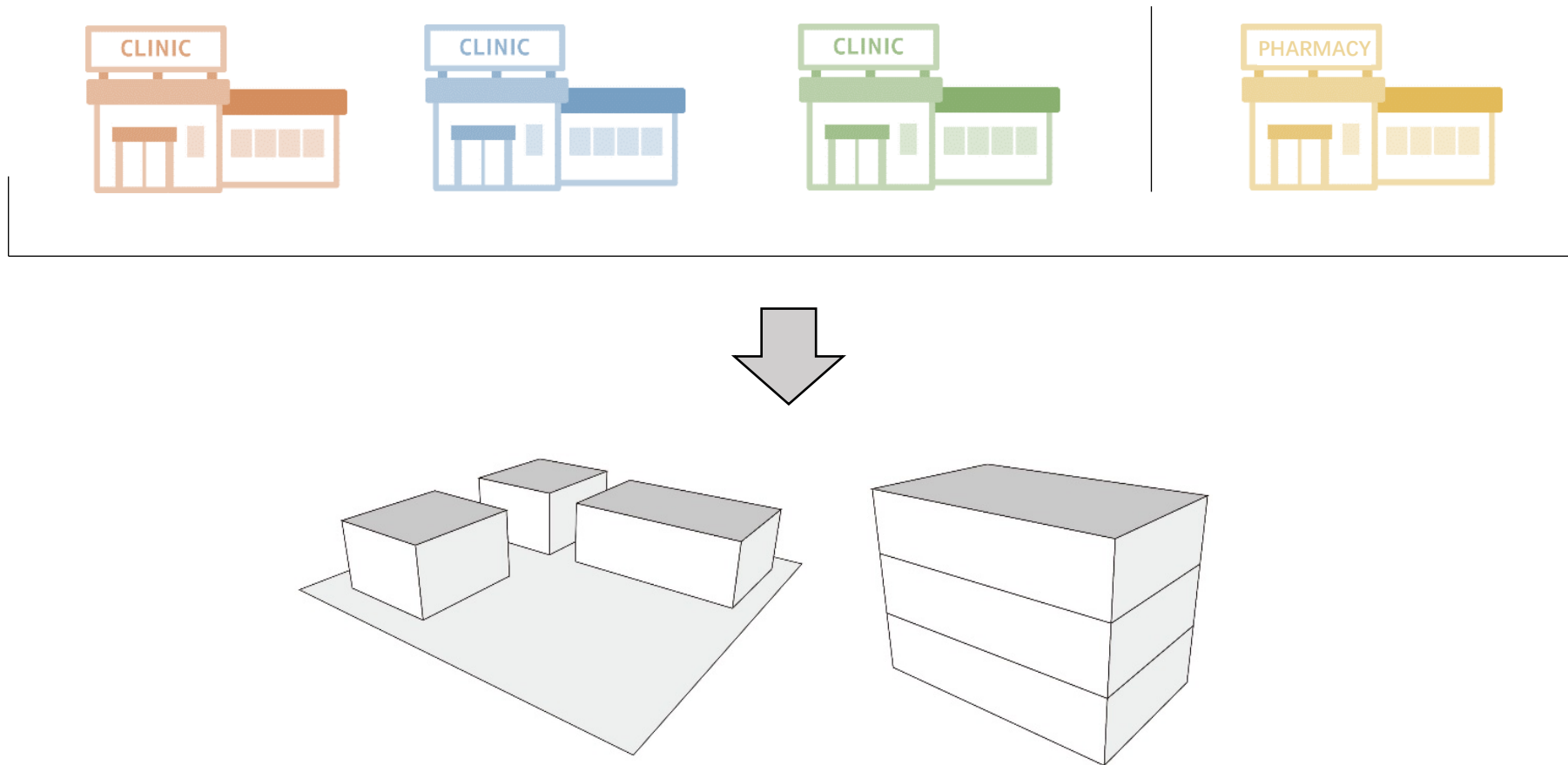
CHARACTERISTIC

✓ Medical testing facilities, receiving desks, management departments, pharmacies and other facilities are shared to save resources and improve efficiency. Doctors can cooperate with each other and the patients wait less time by the sharing reception and equipment.

✓ Meet people's diverse needs, for example, the elderly people can receive consultations from several medical departments in one medical mall.

Ophthalmology

Internal Medicine

General Surgery

Pediatrics

Psychiatry

Dermatology

Age Category	1 - 2 kinds	3 - 4 kinds	5 - 6 kinds	over 7 kinds
Upper 75 years	34.1	24.8	16.3	24.8
65 - 74 years	43.5	28.6	14.4	13.6
40 - 64 years	46.6	30.0	13.5	10.0
15 - 39 years	45.4	32.6	14.6	7.4
0 - 14 years	39.0	32.2	18.3	10.5

Number of Medicine types in each Age Category

The Analysis of Medical Efficiency and Location Tendency of the Medical Mall in Fukuoka City

PURPOSE

Clarifying the medical efficiency of medical mall quantitatively and compare with other clinics.

Clarifying the location tendency of medical mall, based on the medical efficiency.
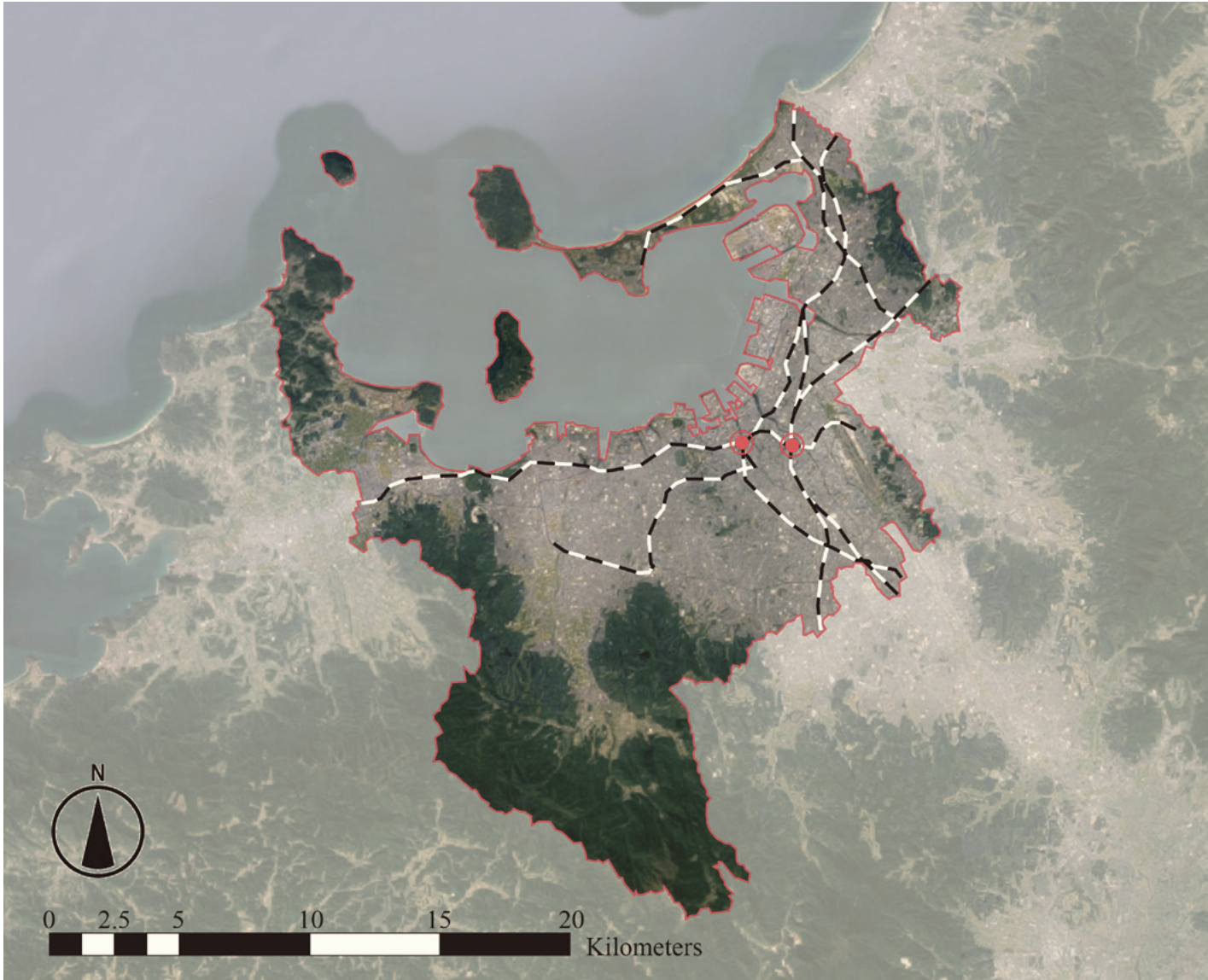
Under such background and demand, this study takes the medical facilities of Fukuoka, a typical local central city in Japan, as the research object, aiming to analyze the service efficiency and spatial distribution characteristics of the medical mall with the help of quantitative methods, and explore the best location conditions.

The research targets are the clinics and the medical malls located in Fukuoka City. There are 115 hospitals, 1526 clinics (which include **75 medical malls**) and 1013 dental clinics, carried out by the Fukuoka City government in August 2018.

The medical malls are divided into 3 types, village-type, building-type and attachment-type according to the Spatial combination.

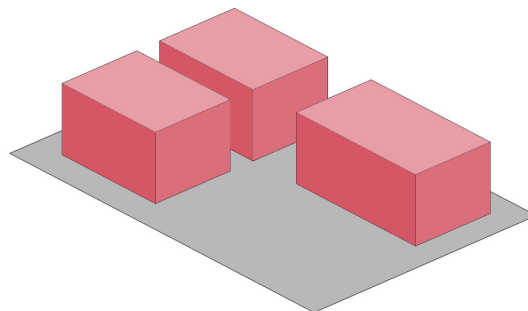| Type	Definition
Village-type	Multiple single-family clinics gather on individual site
Building-type	Various clinics occupy the whole small building
Attached-type	Several clinics occupy one floor of an office or commercial building

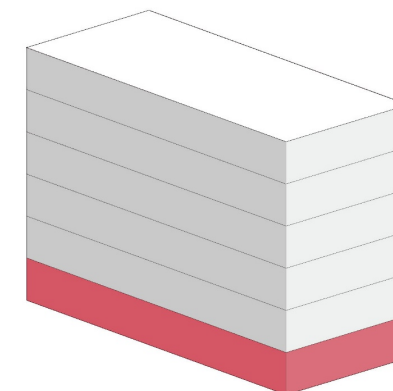## Building-Type

Imafuku Tsurumi Medical Mall
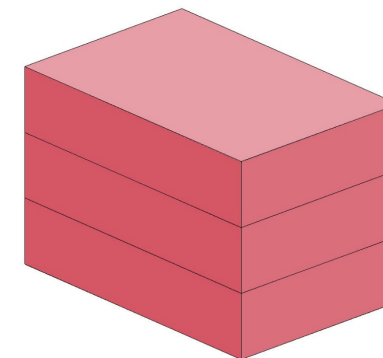
Village-Type

Tsukiguma Medical Mall

Attachment-Type

Medical Mall Toyosu

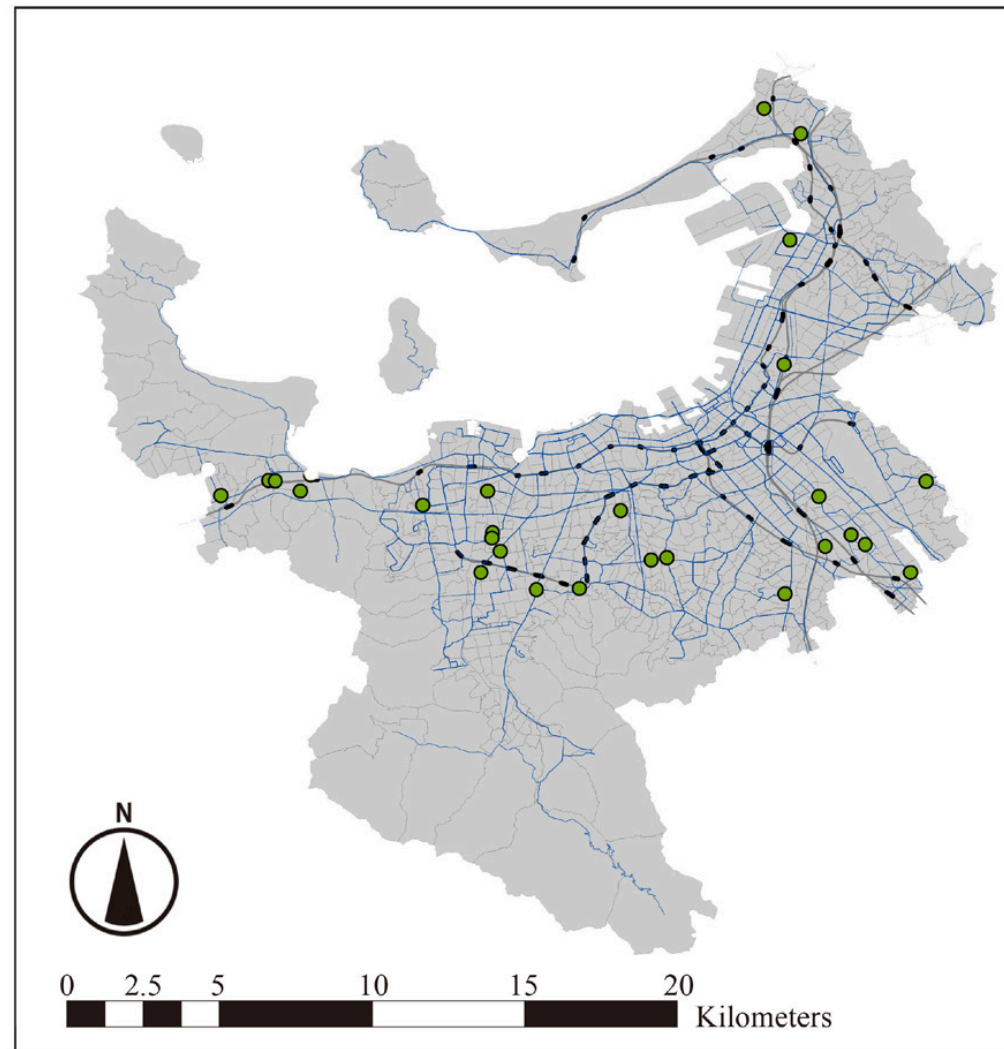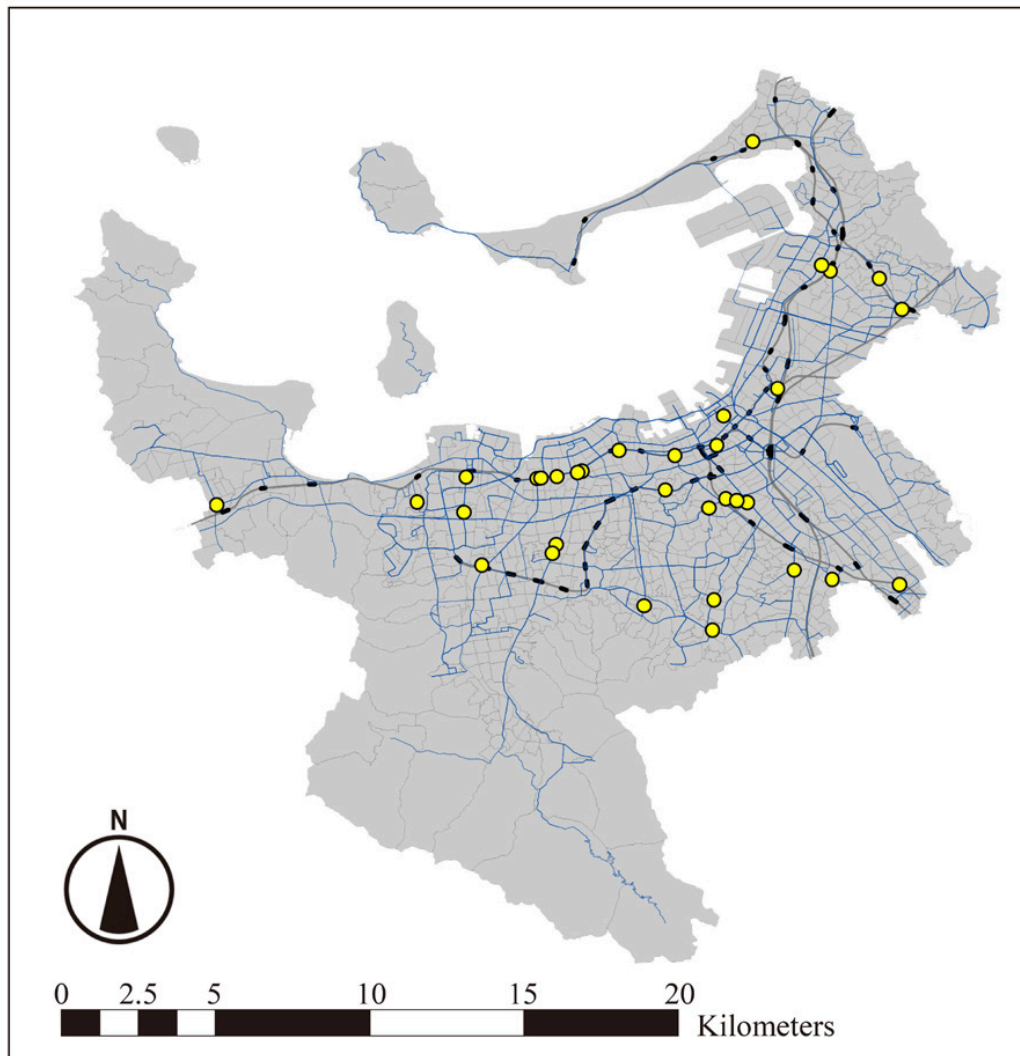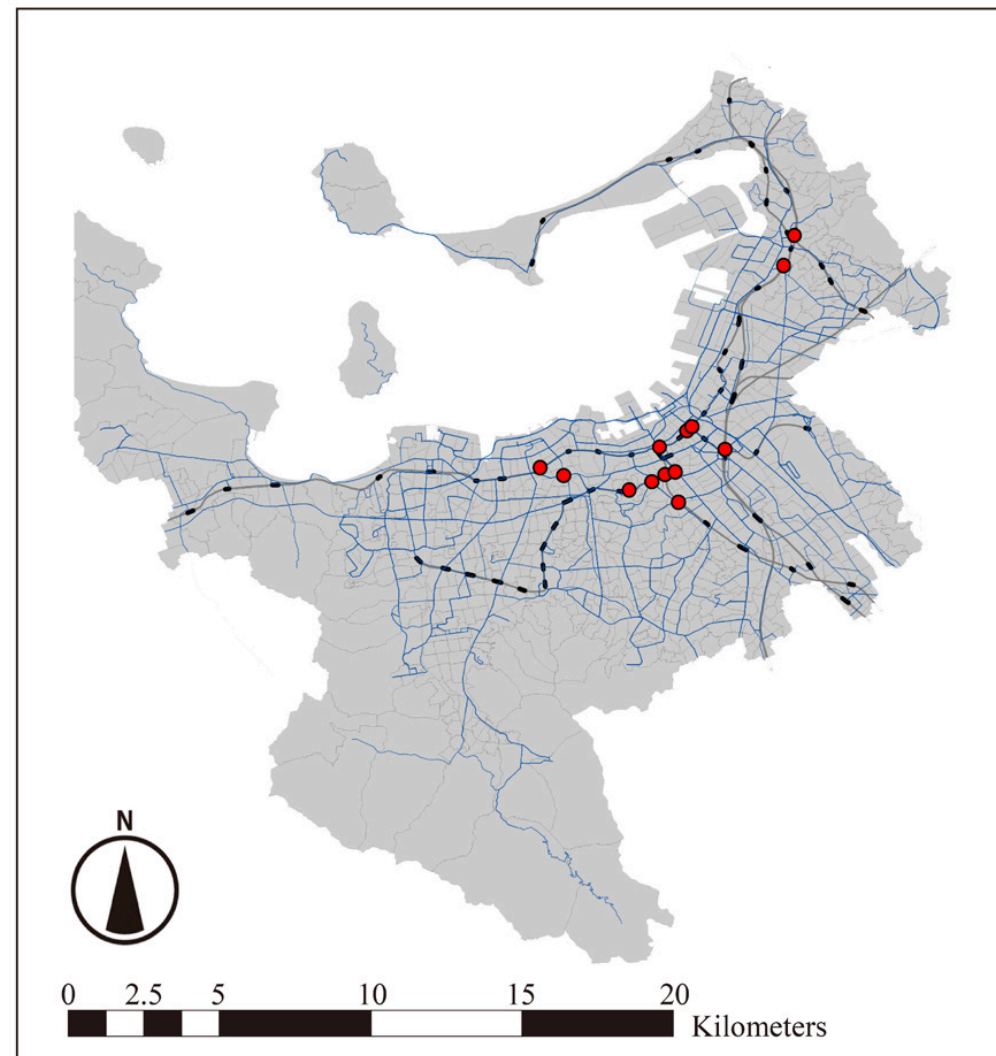The Analysis of Medical Efficiency and Location Tendency of the Medical Mall in Fukuoka City
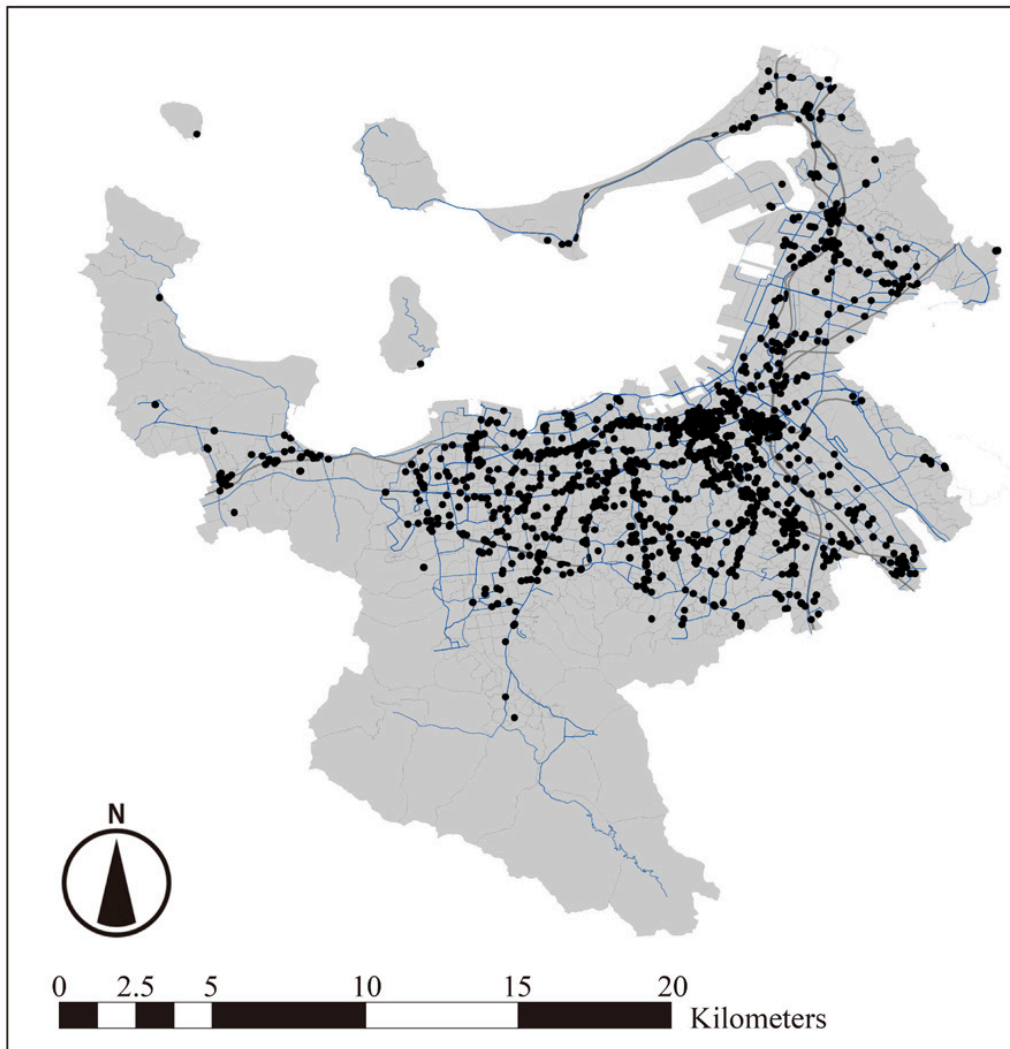
Clinics （1526）

Village-Type （30）
Mainly located in the suburban area.

Building-Type（33）
Located in whole area.

Attachment-Type（12）
Mainly located in the central city.

Data Envelopment Analysis （DEA）

DEA is the method to estimate productivity without parameter estimation based on the statistical way.
Also, DEA is an effective method for evaluating the efficiency, and it was used in much previous literature in particular about medical facility.
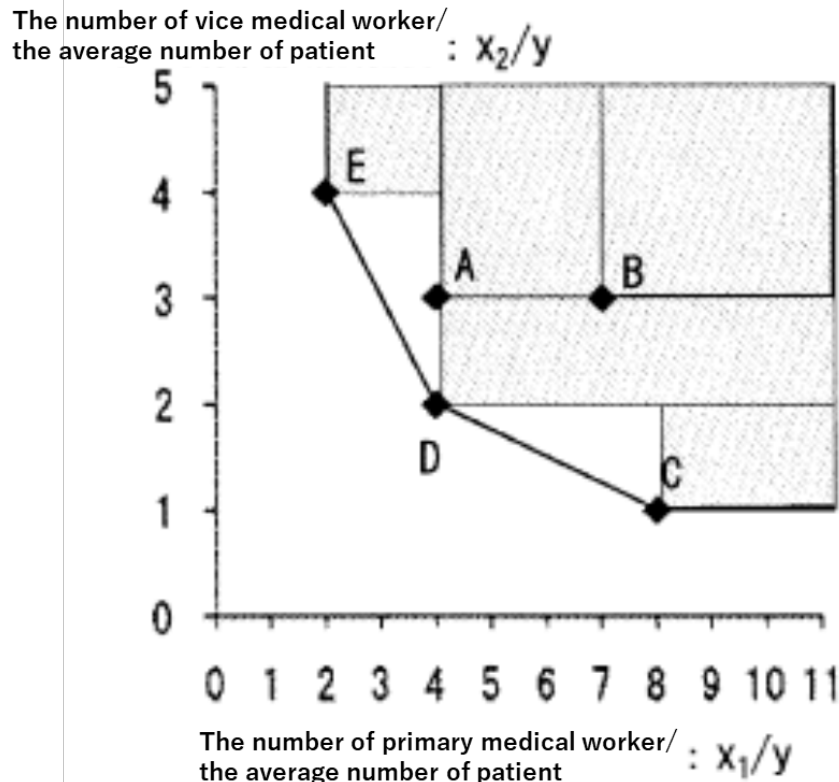
The number of vice medical worker/
the average number of patient : x_2/y

The number of primary medical worker/
the average number of patient : x_1/y

<CCR$_o$> Objective function: $max\theta = u_o y_o$

$$\begin{cases} v_1 x_{1o} + v_2 x_{2o} = y_o \\ u_o y_o \leqq v_1 x_{1j} + v_m x_{mj} (j = 1, \dots, n) \\ v_1, v_2 \geqq 0 \\ u_o \geqq 0 \end{cases}$$

θ : medical efficiency
y_o : the average number of patient per day
u_o : the coefficient of variable capacitance of y_o
x_{1o} : the sum of the number of first medical worker.
x_{2o} : the sum of the number of second medical worker

CCR Model

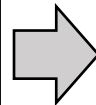The CCR model is a more general form of linear programming for evaluating efficiency. We use "R" as the calculating software.

<CCR$_o$> Objective function: $max\theta = u_o y_o$

$$\begin{cases} v_1 x_{1o} + v_2 x_{2o} = y_o \\ u_o y_o \leqq v_1 x_{1j} + v_m x_{mj} (j = 1, \dots, n) \\ v_1, v_2 \geqq 0 \\ u_o \geqq 0 \end{cases}$$

```
CCR <- function(input, output, dmu) {
        matin <- as.matrix(input)
        matout <- as.matrix(output)
        ndmu <- nrow(matin)
        nin <- ncol(matin)
        nout <- ncol(matout)
        g.in <- c(rep(0, nin), matout[dmu, ])
        g.mat <- rbind(c(matin[dmu, ], rep(0, nout)), cbind(-matin, matout))
        g.dir <- c("=", rep("<=", ndmu))
        g.rhs <- c(1, rep(0, ndmu))
        soln <- lp("max", g.in, g.mat, g.dir, g.rhs)$solution
        return(list(opt=sum(soln[nin+1:nout]*matout[dmu, ]),
                win=soln[1:nin], wout=soln[nin+1:nout]))
}

DEAtable <- function(input, output) {
        n <- nrow(as.matrix(input))
        tbl <- sapply(1:n, function(k) unlist(CCR(input, output, k)))
        return(t(tbl))
}

> library(lpSolve)
> libr <  read.table("clipboard", header=TRUE)
> (input <- libr[, 2:3])
> (output <- libr[, 4:5])

> CCR(input, output, 1)

> (dealib = round(DEAtable(input, output), 6))
```

Database

Input Factor
①First medical worker
Doctor, Pharmacist, Part-time Doctor

②Second medical worker
Nurse, Physical Therapist, Other Sub-medical worker

Output Factor
Patients

Doctor

Part-time Doctor

$\times 0.37$
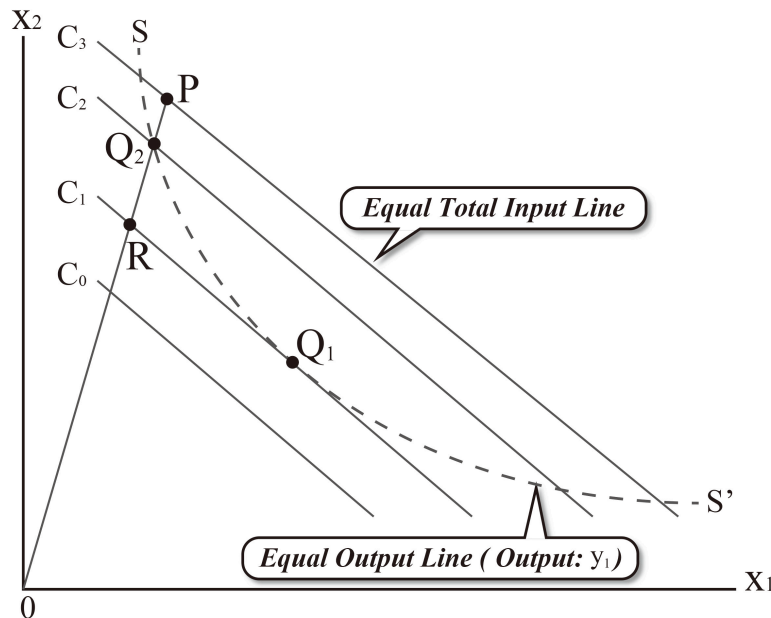
66.7h/week ⟹ 24.5h/week

we correct weighting the number of part-time doctors with 0.37 times, and then add up it with the number of official doctors and pharmacists.

X_2 C_3 S

C_2 P

Q_2

C_1

C_0 R

Equal Total Input Line

Q_1

S'

Equal Output Line (Output: y_1)

X_1

0

Overall Result

Village type > building type > attachment type > clinic

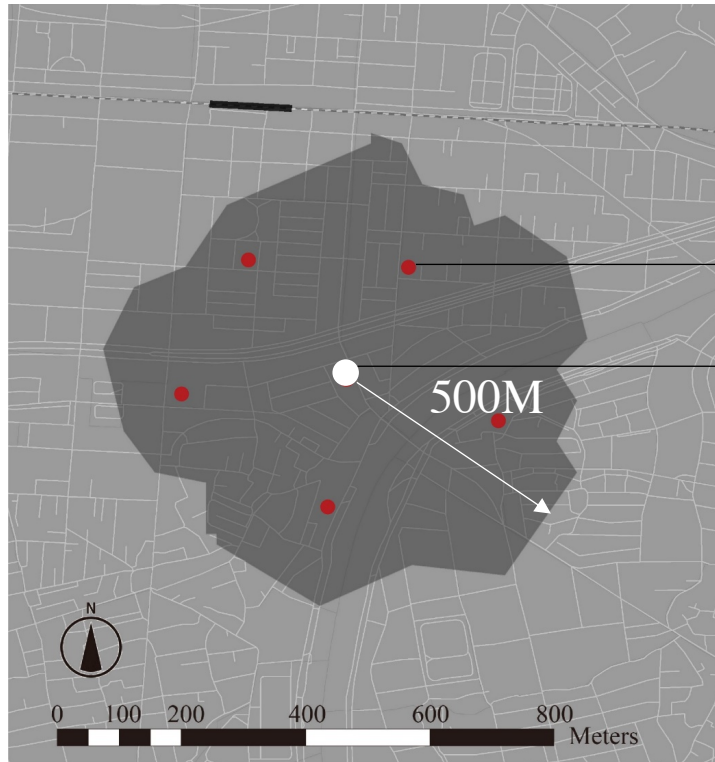|	All Medical Facility	Clinic	Medical Mall	Village Type	Building Type	Attachment Type
Average	0.4236	0.4147	0.4921	0.5742	0.4491	0.4424
Median	0.3807	0.3704	0.4961	0.5446	0.4293	0.4525

Each Medical Treatment Subject

Otorhinolaryngology > Pediatric > Dermatology > Ophthalmology > General Surgery > Psychiatry > Internal Medicine > Obstetrics and Gynecology

	Internal Medicine	General Surgery	Obstetrics and Gynecology	Pediatric	Ophtha-lmology	Otorhino-laryngology	Dermatology	Psychiatry
Average	0.3659	0.4345	0.3005	0.5640	0.4660	0.6131	0.5144	0.3763
Median	0.3333	0.3818	0.2708	0.5754	0.4233	0.6458	0.5500	0.3417

Comparison between the Medical Mall and ICA Clinic
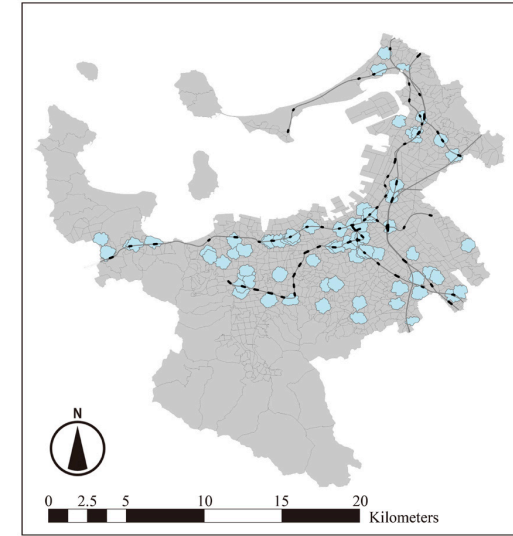
ICA Clinic：clinics in medical mall catchment area

Catchment area：500m walking distance ---10 minutes' walk for the elderly, children or the sick

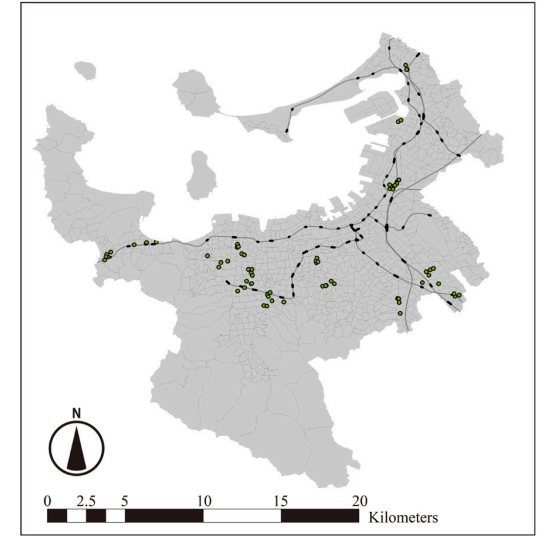
ICA Clinic
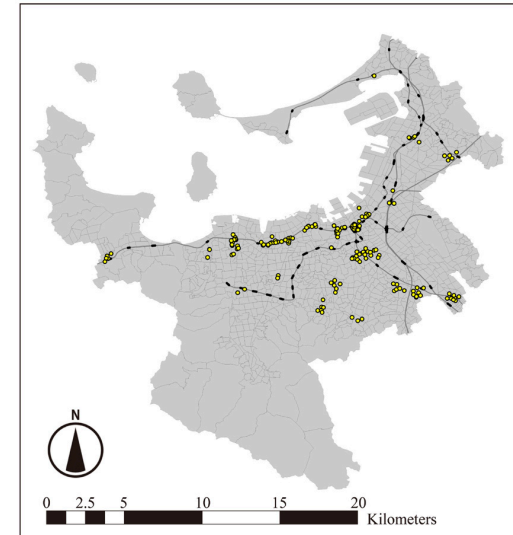
Medical Mall

500M

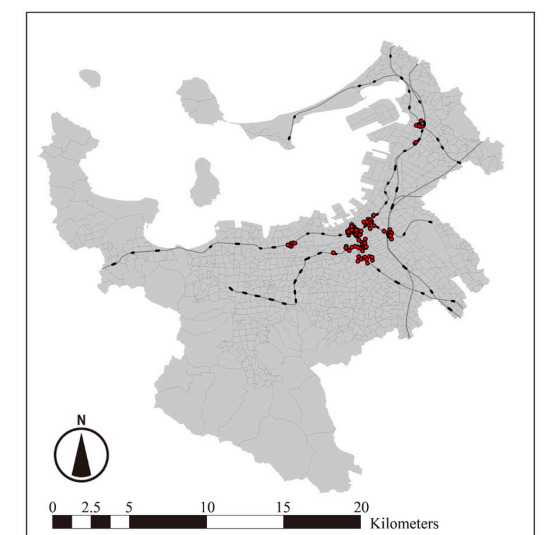Catchment Area and ICA Clinic

Catchment Area of All Medical Malls

ICA Clinic around the Village-Type MM

ICA Clinic around the Building-Type MM

ICA Clinic around the Attachment-Type MM

Comparison between the Medical Mall and ICA Clinic

Medical Efficiency of ICA Clinic by Each Medical Facility Type and Medical Treatment Subject

	ICA-V			ICA-B			ICA-A		
	Number	Average	Median	Number	Average	Median	Number	Average	Median
Internal Medicine	41	**0.3818**	**0.3500**	110	0.3404	0.3086	81	0.3435	0.3086
General Surgery	21	**0.4056**	**0.3700**	48	0.3997	0.3170	36	0.3522	0.2729
Obstetrics and Gynecology	5	0.2981	0.2861	12	**0.3352**	**0.2974**	9	0.2649	0.2287
Pediatric	3	0.4979	0.5779	13	**0.5679**	0.5844	4	0.5637	**0.6235**
Ophthalmology	8	0.4932	0.4750	12	**0.5545**	**0.6186**	12	0.4526	0.4100
Otorhinolaryngology	2	0.5401	0.5401	4	0.6107	0.6349	8	**0.6340**	**0.6045**
Dermatology	6	**0.6609**	**0.6605**	10	0.5172	0.4697	13	0.4581	0.4938
Psychiatry	1	0.1852	0.1852	5	0.3775	0.3700	15	**0.4187**	**0.4167**

The Comparison of the value of medical efficiency between the medical mall and ICA clinic

Type of medical mall	ICA Clinic < **Medical mall**	**ICA Clinic** > Medical mall
Village-type	35	5
Building-type	60	41
Attached-type	65	68

Catchment Area of All Medical Malls
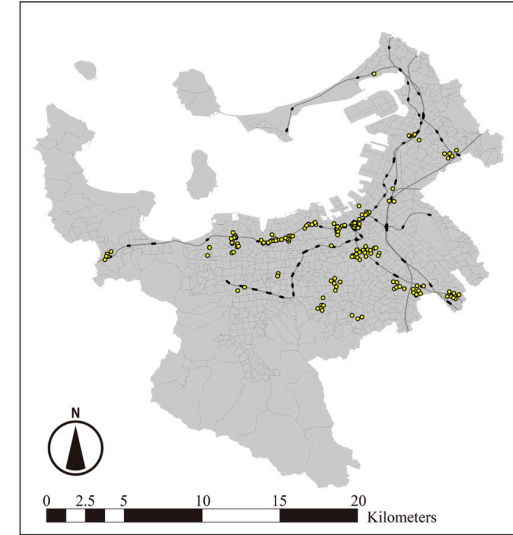
ICA Clinic around the Village-Type MM

ICA Clinic around the Building-Type MM
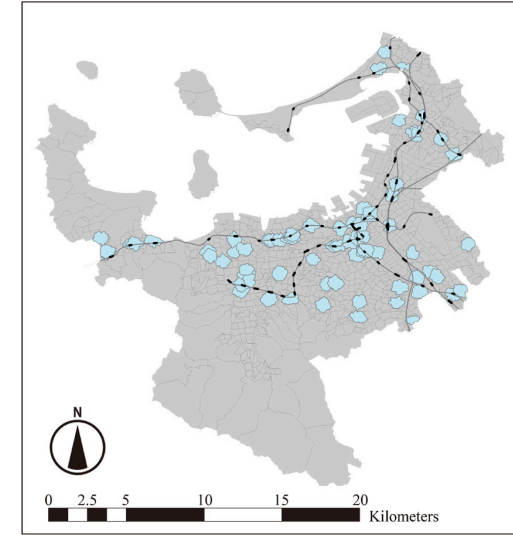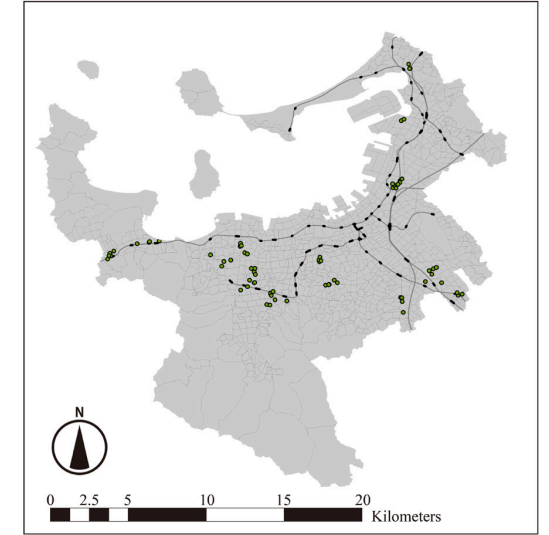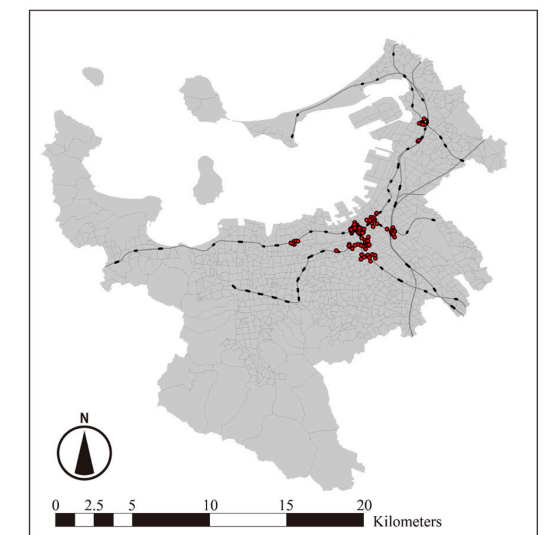

ICA Clinic around the Attachment-Type MM

The Analysis of Medical Efficiency and Location Tendency of the Medical Mall in Fukuoka City

CONCLUSION

✓ The results show that medical malls have a tendency to have higher medical efficiency than clinics. In particular, the village-type is an efficient medical facility.

✓ The medical efficiency is different for different medical treatment subject. Even in this analysis, the village-type showed the highest medical efficiency in many medical treatment subjects, comparing other medical mall types.

✓ In comparing the medical unit and the ICA clinic of a single medical treatment subject, the village-type shows higher medical efficiency in almost all of the medical treatment subjects. The building-type and the attachment-type have slightly higher medical efficiency than the ICA clinic.

5 Factors which described the location environment

Building Function Factors

11 types of building use :residence, office, commerce, industry, medical care, government, education, accommodation, storage, agricultural forestry industries and fisheries.

Demographic and Socioeconomic Environment Factor

Population (divided into 3 groups: young, adult and elderly
the proportion of the upper 75 years
the proportion of working people

Transit-Related Factors

Data about the number of bus stops and railway stations in the medical catchment area, and the distance from the bus stop and the railway station.
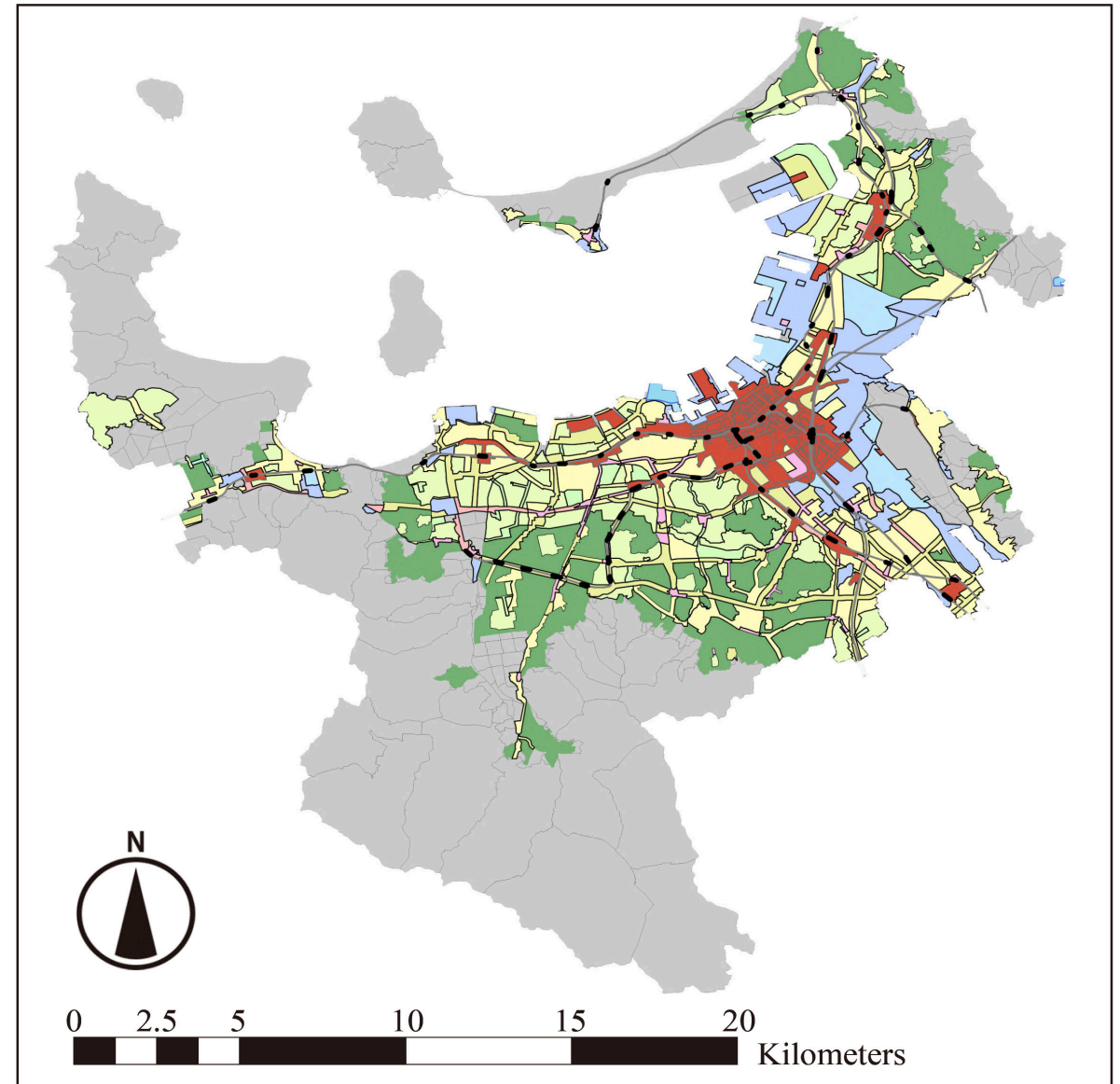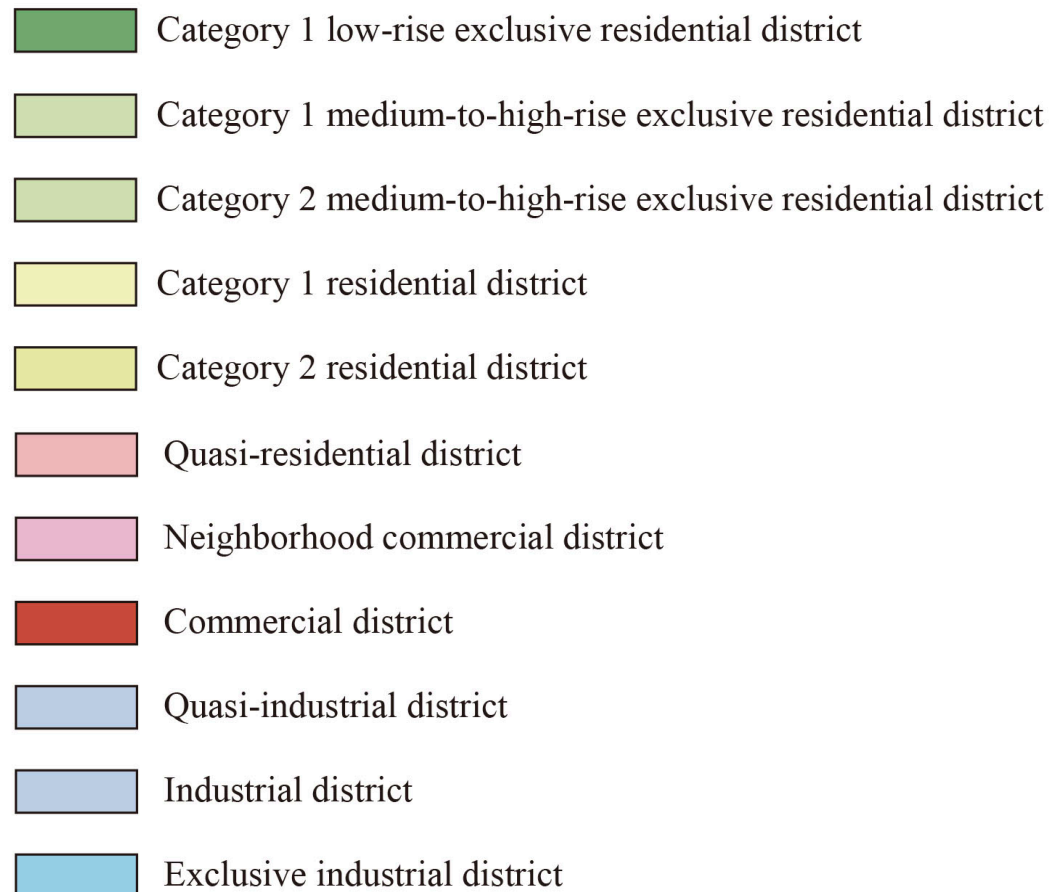Parking lot and the number of car lanes in front of the facility

Land Price

Unit: yen per square meter.

5 Factors which described the location environment

Land use zone in Fukuoka

- Category 1 low-rise exclusive residential district
- Category 1 medium-to-high-rise exclusive residential district
- Category 2 medium-to-high-rise exclusive residential district
- Category 1 residential district
- Category 2 residential district
- Quasi-residential district
- Neighborhood commercial district
- Commercial district
- Quasi-industrial district
- Industrial district
- Exclusive industrial district

N

0 2.5 5 10 15 20 Kilometers

Location environment characters

Location

As is clear from the distribution of each medical mall type, there is the tendency that village-types are located in the suburban area, and attachment --types are located in the urbanized area, and building-types are located in the whole city.

Building-Type

Almost all factors show between that of village-type and attached-type. The only remarkable index is about bus accessibility. It is considered that the bus is significant public transportation for this area.
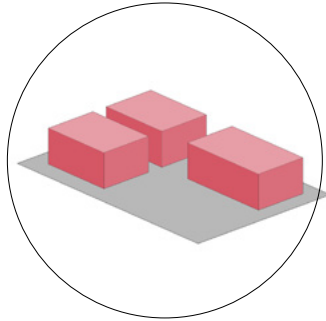
Village-Type

The population is small and the number of the floor of buildings located in the surroundings is not high. The accessibility of public transportation and the private car is not substantial. The number of the parking lot enough for the patient to visit by car than the other two types. Also, the land price is the cheapest. From the above, the location of the village type is adequate for community-based medical care.
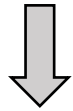
Attachment-Type

It is more specialized for commerce and office, as is clear from the location distribution. In addition, this area has rich accessibility by public transportation and car, especially by the railway, compared with the other types. Also, many people live in surround, and the proportion of working people is higher than that of the other types. Furthermore, the land price is highest.

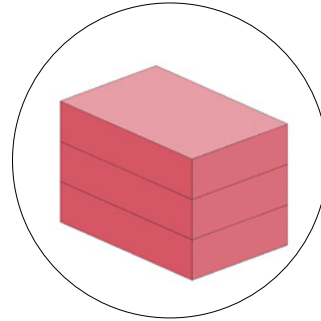Relationship between Medical Efficiency and Location Condition

Village-Type
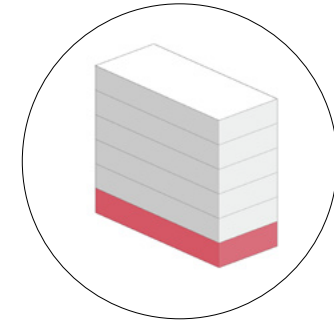
Parking lots
The number of car lanes

⬇

Private Car

Building-Type

High medical demand area
(not obvious)

⬇

Reputation

Attachment-Type

Accessibility to public transportation
high land price

⬇

Public Transportation
Shopping or Working

5 CONCLUSION

✓ Medical mall is a new medical facility and can be divided into 3 types according to the spatial form in Fukuoka city, which are Village-Type, Building-Type and Attachment-Type.

✓ Medical malls have higher medical efficiency than clinics by using CCR model of DEA, a method to calculate the efficiency of facilities.

✓ Different medical mall type has different location tendency (building function factor, transit-related factor, demographic and socioeconomic environment factor, the land price, and land use zone). The medical efficiency of the medical mall is also related to the location tendency.

THANKS