A SIMULATION MODEL FOR DENTAL DISEASES

Toshiro Shimada   Meiji University, Tokyo, Japan
Kenji Fukushima and Hirokazu Mizushima,
                  Japan Dental Association, Tokyo, Japan
Kinya Machida,   Asahi University, Gifu-shi, Japan
Akira Uchino,   Yokohama College of Commerce, Yokohama-shi, Japan

ABSTRACT

Dental diseases dealt with in this study are cavities (fillings, extractions and crowns), pyorrhea and baby teeth.

The total number of teeth with dental diseases in Japan changes year by year depending on oral conditions and are affected by the number of dentists, economic conditions and technical progress.

This model contains 4 sectors: demography, cavities , pyorrhea and baby teeth. The demographic sector covers populations of 5 three-year age groups under 14 years of age and 13 five-year age groups above 15 years of age. The cavities sector and pyorrhea sector are composed of populations of five-year age groups, on the other hand, the baby teeth sector uses populations of three-year age groups.

From the total number of defective teeth, dental busyness and total dental care costs in Japan are calculated yearly from 1963 to 2010. The simulation results are used to modify the dental policies of Japanese administrators.

This study is a research project of the Japan Dental Association.

1. MODEL FOR DENTAL DISEASES

1. 1 Parts composing the model

This model containes 4 sectors: demography, dental caries, pyorrhea and baby teeth. In each sector we deal with the whole of Japan. Relations among sectors are shown in Fig.1.

Fig.1
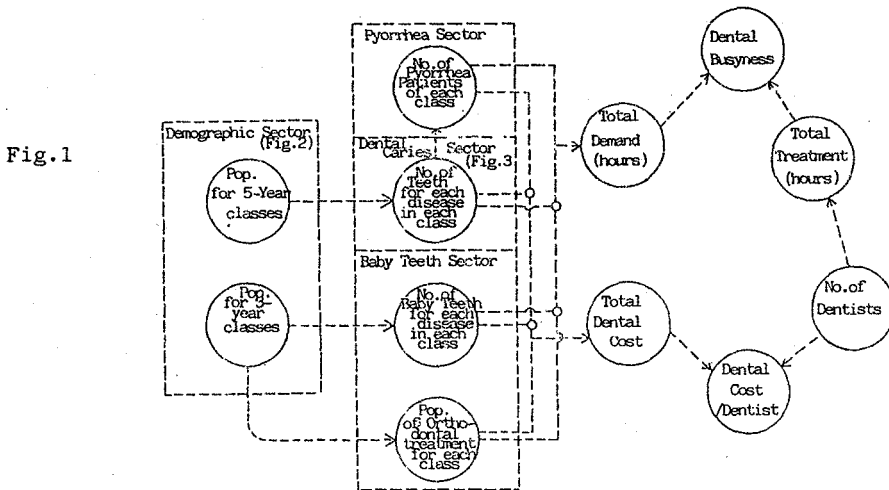
1. 2 Demographic Sector

The demographic sector covers populations of 5 three-year age classes under 14 years of age and 13 five-year age classes above 15 years of age. The former are the classes 0-2, 3-5, 6-8, 9-11 and 12-14 years of age, and the latter are the classes of 15-19 ,20-24, ..., (70-74) and 75~ years of age. Population of each age class is a level depending on the rates of entering and leaving. The first age class Z0 is entered by births and left by aging out and deaths in the age class. Other age classes Z3, Z6,.....,Z75 are entered by aging out of the previous age class and left by either aging out of this age class or through death.

The flow diagram of this sector is shown in Fig.2.

1. 3 Dental Caries Sector

The Dental Caries Sector has 13 subsectors corresponding to 13 five-year classes of the population sector.

Dental caries are classified as follows:

Healthy teeth: Carious symptoms and dental care are not recognized.

C_0 : Similar to healthy teeth, but there is indecision as to whether teeth are decayed or not.

C_1 : Small surface cavities which may be easily filled and treated.

C_2 : cavities worse than C_1, but health may be restored by fillings without pulpectomy.

C_3 : cavities worse than C_2, after pulpectomy, in some cases decayed teeth are only filled, but generally metal crowns may be used. In the case of front teeth complete care of bridges may be necessary.

C_4 : Carious symptoms are serious to the point that decayed teeth must be extracted and a denture may be necessary.

The meaning of variables may be self-explanatory in Fig.3. The word 15 seen in variable names means the Z15 population class.

The number of C_1 teeth is first computed. Then C_2, C_3, C_4, filled teeth, crowns and bridges, Missing teeth and dentures are successively computed as seen in Fig.4.
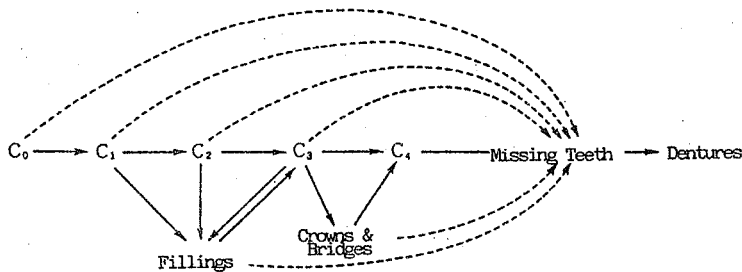

Fig.4

Other dental caries subsectors are quite similar to the one for the Z15 population subsector.

Data for this sector have all been collected by the Japan Dental Association.

3-Year Age Classes

5-Year Age Classes

Death Rate S0C	Death Rate S3C	Death Rate S12C	Death Rate S15C	Death Rate S20C	Death Rate S25C	Death Rate S30C	Death Rate S35C	Death Rate S40C	Death Rate S70C	Death Rate S75C

Deaths S0 | Deaths S3 | Deaths S12 | Deaths S15 | Deaths S20 | Deaths S25 | Deaths S30 | Deaths S35 | Deaths S40 | Deaths S70 | Deaths S75

Pop. Z0 0~2 | Pop. Z3 3~5 | Pop. Z12 12~14 | Pop. Z15 15~19 | Pop. Z20 20~24 | Pop. Z25 25~29 | Pop. Z30 30~34 | Pop. Z35 35~39 | Pop. Z40 40~44 | Pop. Z70 70~74 | Pop. Z75 75~

Births 10

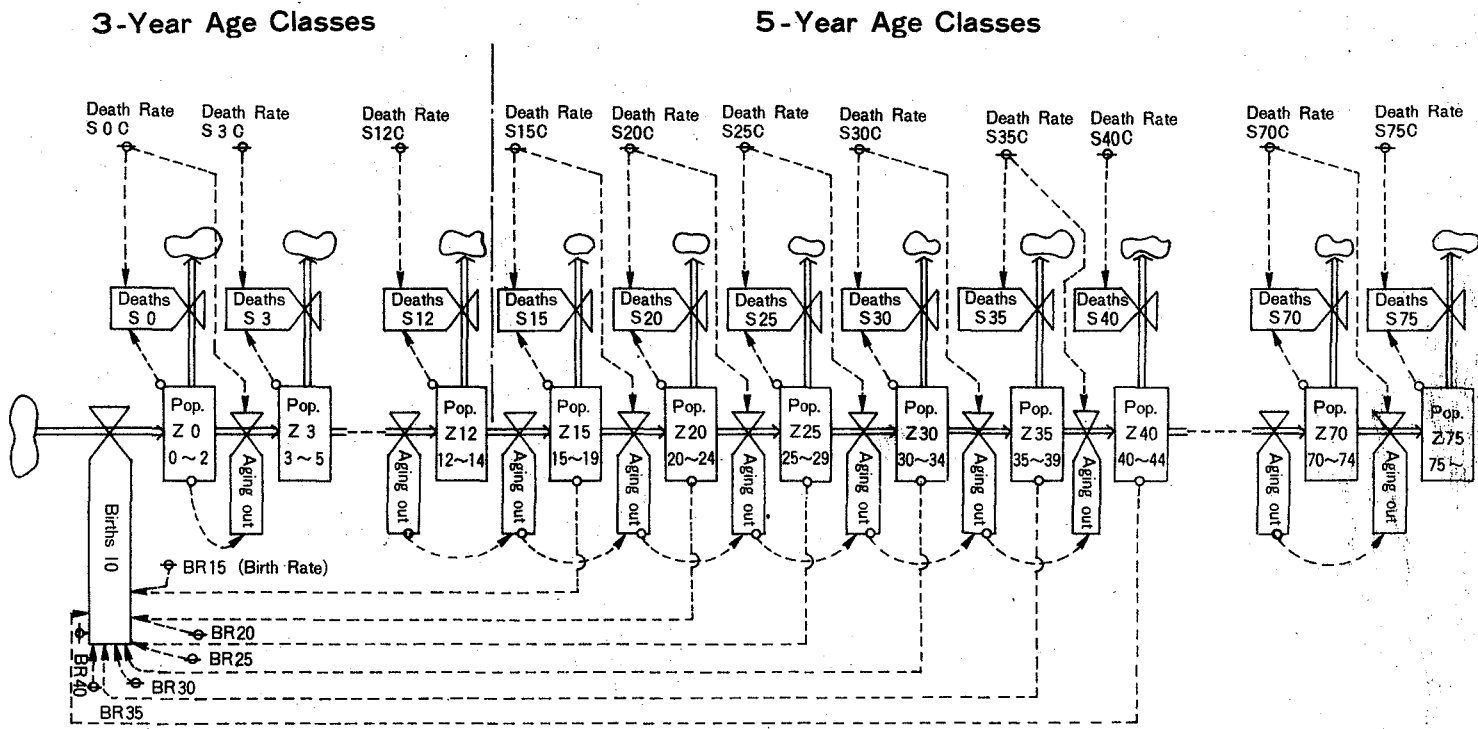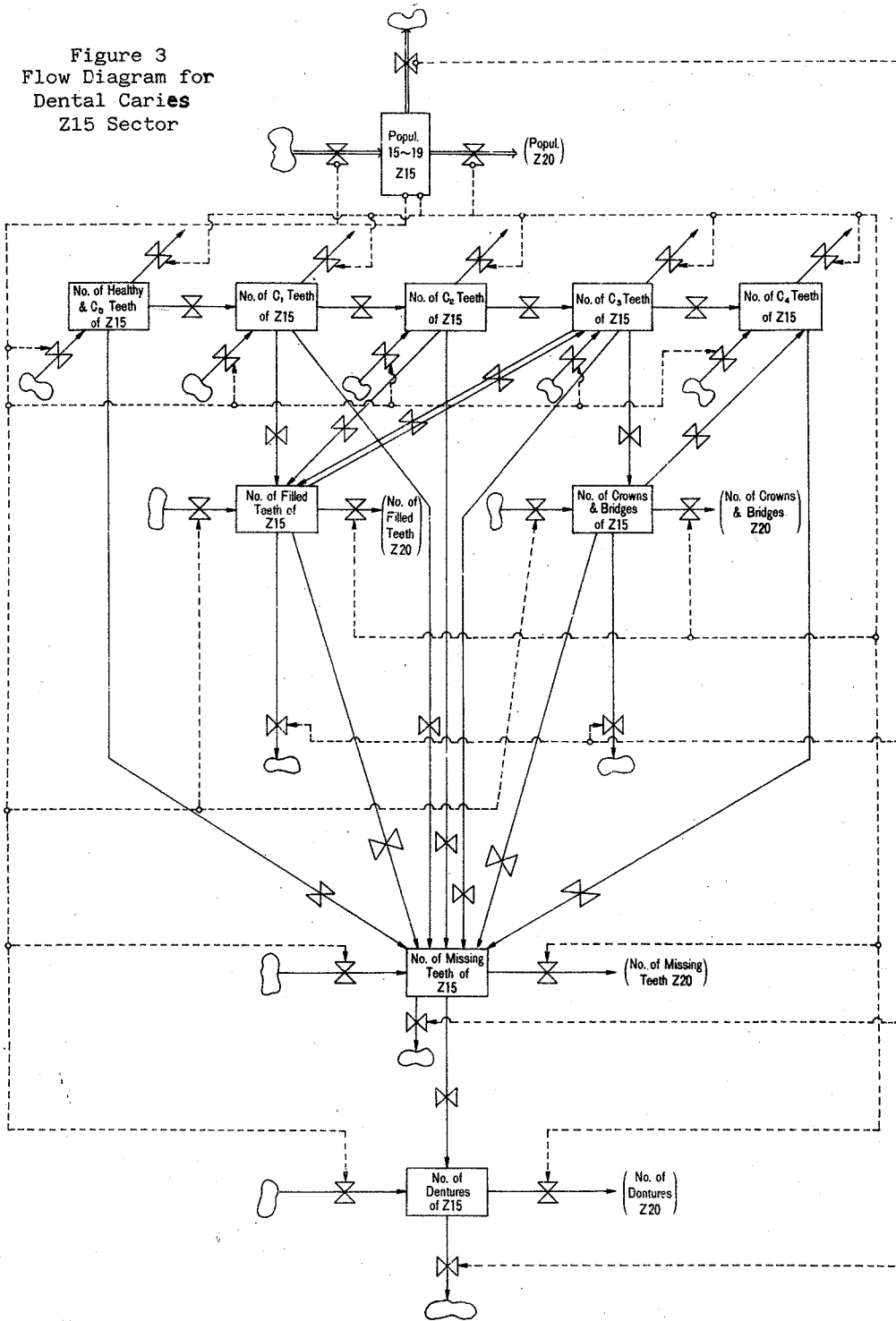Aging out

BR15 (Birth Rate)
BR20
BR25
BR30
BR35
BR40

Figure 2 Flow Diagram for Demographic Sector

Figure 3
Flow Diagram for
Dental Caries
Z15 Sector

1. 4 Pyorrhea Sector

1. 4. 1 The Patient Population for C_1, C_2 and C_3

The patient population for C_1, C_2 and C_3 is obtained from the sum of C_1, C_2 and C_3 teeth for five-year age classes divided by the number of C_1, C_2 and C_3 teeth per patient.

1. 4. 2 The Periodontal Patient Population for Each Age Class

This variable may be obtained from the above population for C_1, C_2 and C_3 times the ratio of periodontal patients to C_1, C_2 and C_3 patients.

1. 4. 3 Cost of Periodontal Treatment

This variable may be calculated from the sum of the above population of periodontal patients for each age class times the cost for treatment per capita.

1. 5 Baby Teeth Sector

1. 5. 1 Number of Defective Baby Teeth

The number of defective baby teeth for a three-year age class is obtained from the population of the class times 20 teeth per capita times the rate of defects or disease.

1. 5. 2 Cost of Baby Teeth Treatment

This variable may be computed from the total sum of the number of treated baby teeth for each defect or disease and for each age class times the cost per tooth.

2. Orthodontic Treatment

First the patient population for orthodontic treatment is obtained from the sum of the population of each age class times the rate of patients for orthodontic treatment.
The total cost in Japan for orthodontic treatment can be calculated from the above population for orthdontic treatment multiplied by the cost per patient.

3. Changes in the Increase of Dentists and Dental Busyness

The number of dentists will increase in the future. From 33,700 in 1963 it is estimated that it will reach about 3.5 times this figure in 2010.
In order to investigate the influence of an increase in the number of dentists on dental treatment, we will consider a variable, termed dental busyness, such that

$$\text{dental busyness} = \frac{\text{total demand (hours)}}{\text{total treatment (hours)}}$$

, where total demand is obtained from the sum of necessary hours for filling C_1, C_2 and C_3 teeth, for crowns and bridges, and for dentures, on the other hand, total treatment is the number of dentists times 2,400 hours/year/dentist.

4. Dental Cost

4. 1 Total Dental Cost

Total dental costs in Japan (CHIHI) are obtained as follows;
    CHIHI= total demand $\times$ unit cost
        total demand (hours)
        unit cost (¥1000/hour/dentist)
Unit cost per dentist per hour is obtained from the model for a Japanese dental office.[2]

4. 2 Dental Cost per Dentist

The value of this variable is CHIHI divided by the number of dentists and means the dentist's income per capita.

4. 3 Dental Costs per Capita

This is CHIHI divided by the population above 15 years of age.

5. SIMULATION RESULTS

Fig.5 and Fig.6 are the simulation results of the base model as to the number of defective teeth, dental cost and dental busyness from 1963 to 2010, respectively.

6. CONCLUSION

We have attempted to formulate a System Dynamics model for dental diseases, which has four sectors of demography, dental caries, pyorrhea and baby teeth.

We showed two simulation results with regard to the number of defective teeth, dental cost and dental busyness, for which the length of the simulation was 48 years from 1963 to 2010.

The simulation results are used to modify the dental policies of Japanese administrators.

This study is a research project of the Japan Dental Association.

REFERENCES

1.Hirsch, Gary B. and W.R.Killingsworth,"A new Framework for Projecting Dental Manpower Requirements",Pugh-Roberts Associates, Inc.,pp 1-63.
2.Shimada Toshiro and K.Fukushima, " A System Dynamics Model of a Japanese Dental Office", Proceedings of the International Conference on Cybernetics and Society, pp 538-543, 1980.
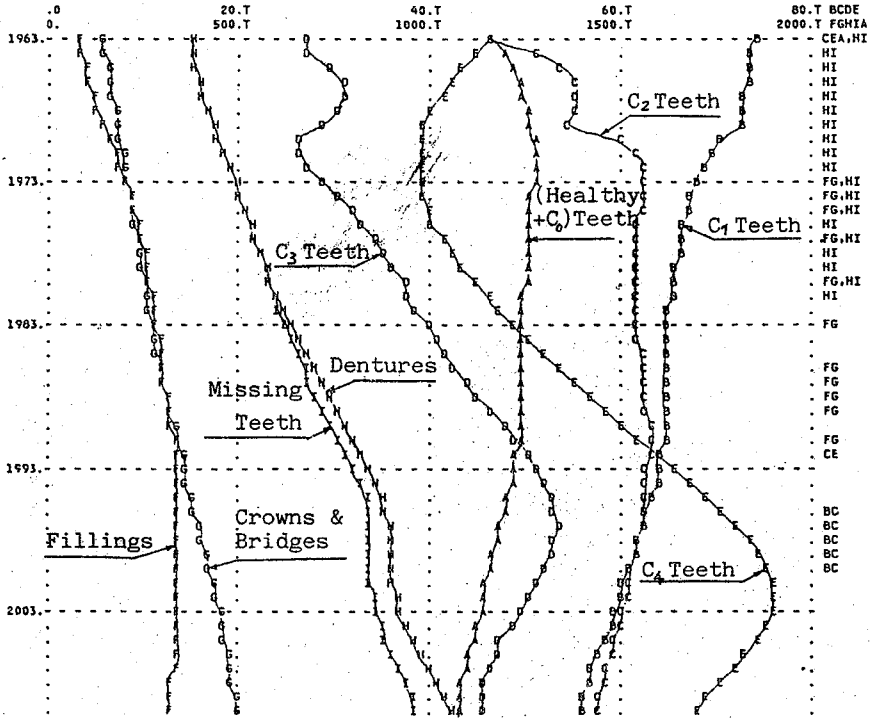
YBC1=B,YDC2=C,YBC3=D,YBC4=E,JTC=F,KTC=G,HTC=H,SOC=I,YBC0=A

Figure 5
Number of
Defective
Teeth
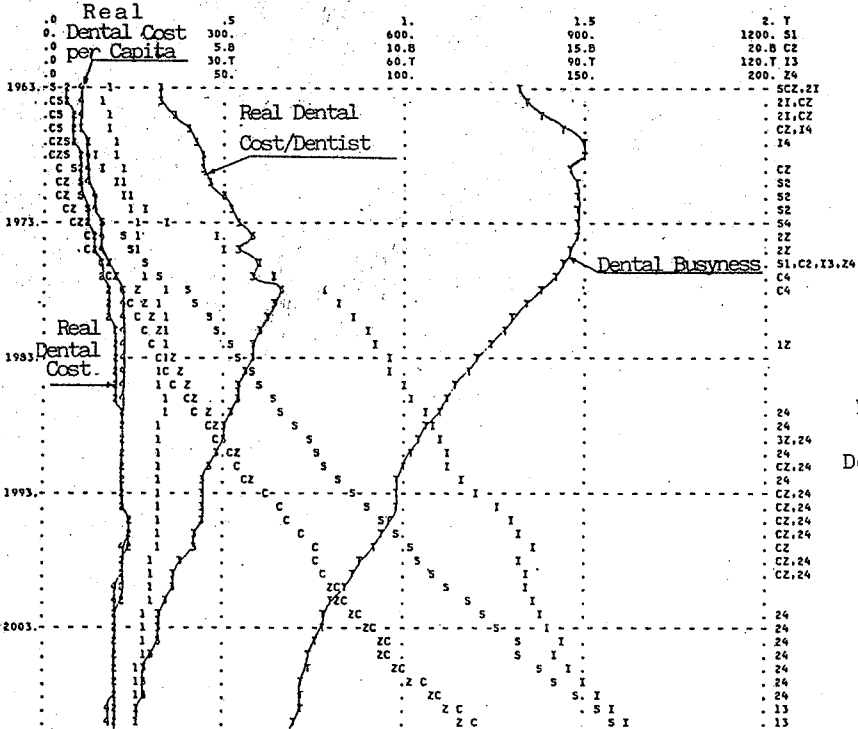
TDD=T,SORI=S,SORIO=1,CHIHI=C,CHIHIO=2,CIHII=I,CIHIIO=3,CIHIZ=Z,CIHIZO=4

Figure 6
Dental Cost
and
Dental Busyness