

Investigation of influence of daily food intake on the health and growth of children

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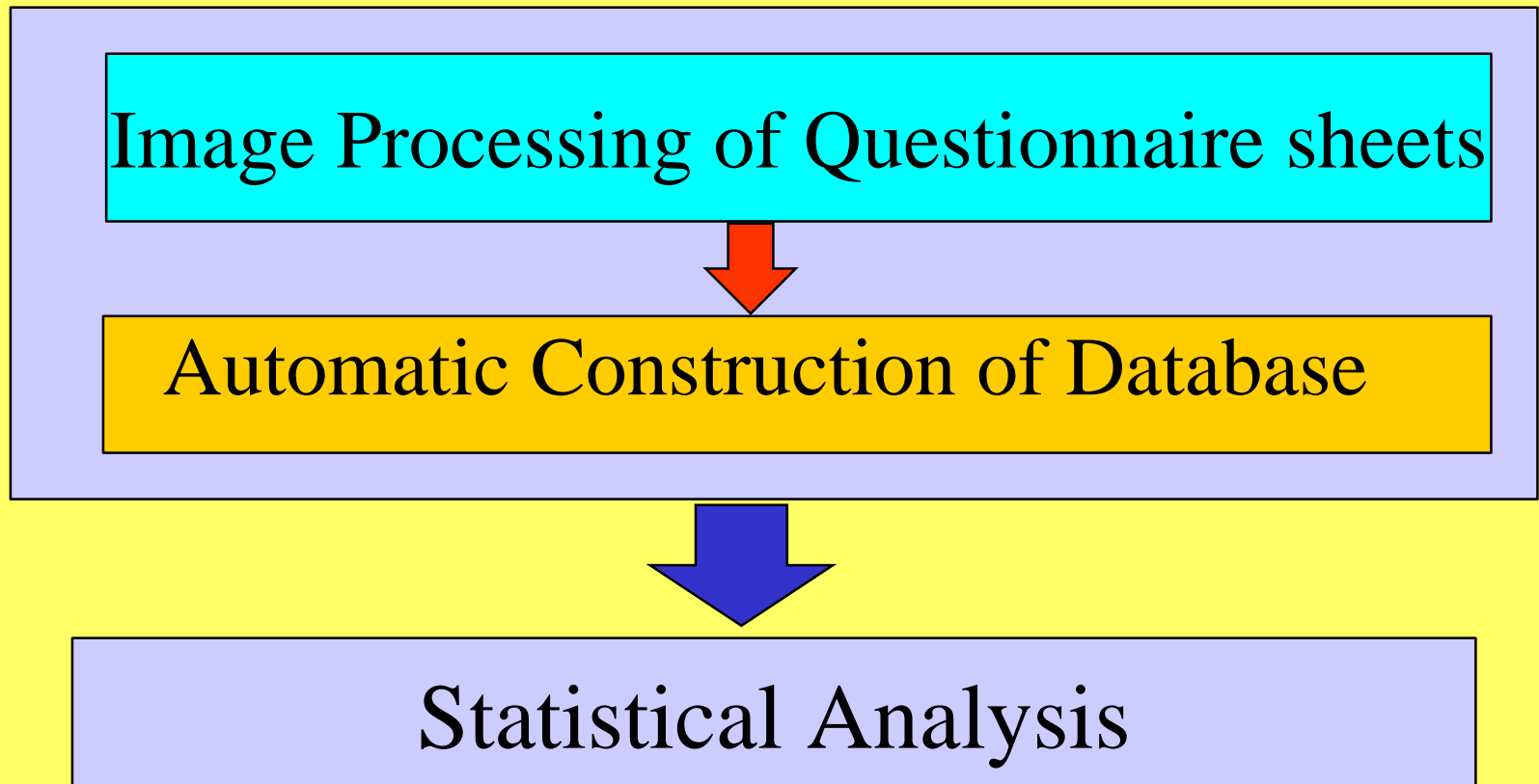
**Yokohama National University, Yokohama Japan

Study by Working Group of Child and Health
of Japan Society of Health Sciences

about 10,000 6-15 years old Children
(Elementary & Middle High Schools)

Chiba, Fukui, Hokkaido, Iwate, Kagoshima,
Kanagawa, Kouchi, Shiga, Shizuoka,
Wakayama and Yamaguchi

Data Processing of Questionnaires



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graph TD; A[Image Processing of Questionnaire sheets] --> B[Automatic Construction of Database]; B --> C[Statistical Analysis];
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Image Processing of Questionnaire sheets

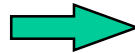
Automatic Construction of Database

Statistical Analysis

Quantification Method

Quantification of Quality

Non-numerical
Expression



Numerical Expression

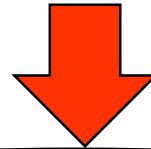
Human Inference Process



Application to Statistical Analysis

Conventional Quantification Theory

Increase in Numbers of Categories
Large Memory for Calculation



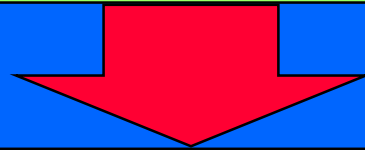
Introduction of Fuzzy Theory



Natural Data Handling and Analysis
by Introduction of Fuzzy Categories

New Method to be Requested

Difficulty in Dealing with
Phenomena
by Rigid Mathematical Model



Mathematical Dealing with
Phenomena
by Verbal Description

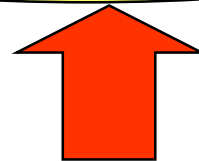
Effectiveness of Fuzzy Theory on the Statistical Analysis

- Fuzzy Analysis of Questionnaires
in the Practical Investigation

- Comparison with the Conventional Method

Fuzzy Quantification Type I

Quantitative Object Variable
(External Standard)
related to
Qualitative & Characteristic Description
(Descriptive Variable)



Regression Analysis

Fuzzy Quantification Type II

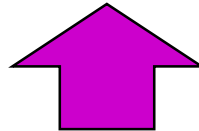
Effect of Qualitative Variables
on Concerned External Standard



Assignment of Optimal Values to
Qualitative Variables Relating
to the Concerned Qualitative Variables

Fuzzy Quantification Type III

Pattern Classification of Elements



Appearance of Correlation Matrix
Elements around Diagonal parts of the Matrix

Purpose of Investigation

(I) Awareness of effect of sweet foods

- ① Knowledge about sweet
- ② Favorite of sweet
- ③ How to take sweet?
- ④ When to take sweet?
- ⑤ Habitual and Recent Intake of sweet
- ⑥ Intake of sweetener
- ⑦ Sweet snacks

(II) Daily diet rule and attention to Health

- ① Meal as a regular habit
- ② Snacks
- ③ Late-night Snack
- ④ Main Meal (Breakfast, Lunch and Supper)
- ⑤ Staple food and subsidiary food
- ⑥ Vegetable
- ⑦ Processed food
- ⑧ Synthetic flavoring matter, sweetener
- ⑨ Fast food

(Ⅲ) Character and Physical Constitution

- ① Physical and psychological change
- ② Change in Behavior

(Ⅳ) Everyday Life

- ① School Life
- ② Intercourse with schoolmates
- ③ In a private school
- ④ Study at home
- ⑤ Free time

(V) Injuries and Diseases

- ① Physical robustness
- ② Number of dental caries
- ③ Fracture of a bone

(VI) Family and Patrons

- ① Members of family
- ② Most effective member to the child
- ③ Life with parents
- ④ A door-key child?
- ⑤ Contact with family member
- ⑥ Consideration and control of Meal
- ⑦ Parents' attitude regarding child
- ⑧ Familial diseases

From 1st Eigenvalue to	Cumulative contribution Rate		
	Fuzzy	Partially fuzzy	Non-fuzzy
2nd Eigenvalue	0.24	0.25	0.22
3rd Eigenvalue	0.45	0.45	0.40
4th Eigenvalue	0.60	0.60	0.55

Type III Fuzzy Group: Awareness of Sweet

Fuzzy Quantification Theory

- Quantification by Assignment of Fuzzy Set to Categories
- Unification and Quantification of Plural Items by Using Fuzzy Set

Example-1 Analysis by Fuzzy Quantification Theory Type I

Relation among “Sugar Intake”, “Vegetable Intake”, “ Processed Food”,
“Regularity of Meal” and ”Character and Physical Constitution”

(1) Amount of Sugar intake

Little	▪ motivated	▪ gentle	
Much	▪ soon tired ▪ nervous	▪ selfish ▪ easily catch a cold	▪ easily nosebleed

(2) Amount of vegetable intake

Little	▪ willfulness ▪ soon tired	▪ easily have a quarrel ▪ dizziness	
Much	▪ very patient	▪ active	▪ always make efforts

(3) Processed food

high rate intake	▪ wearisome ▪ laxative	▪ easily catch a cold ▪ always worry oneself	
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(4) Regularity of Meal

irregular intake	▪ selfish ▪ easily tired	▪ laxative ▪ no willing	
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Example -2 Analysis by Fuzzy Quantification Type II

Relation between “Intake Sugar and Intake Vegetable” and “Character and Physical constitution”

① (Little Sugar, Much Vegetable):

tendency of relatively desirable effect

② (Much Sugar, Much Vegetable), (Little Sugar, Little Vegetable):
not peculiar effect

③ (Much Sugar, Little Vegetable): tendency to undesirable effect

- selfish
- soon tired
- easily have a cold
- fatigue of the eyes
- sticky about someone
- gentle
- very patient
- honesty

Number ω	External standard y	Fuzzy Category					Fuzzy Group B
		A_1	...	A_i	...	A_K	
1	y_1	$\mu_1(1)$	...	$\mu_i(1)$	...	$\mu_i(1)$	$\mu_B(1)$
2	y_2	$\mu_1(2)$	...	$\mu_i(2)$	...	$\mu_i(2)$	$\mu_B(2)$
.
.
.
ω	y_ω	$\mu_1(\omega)$	...	$\mu_i(\omega)$	...	$\mu_i(\omega)$	$\mu_B(\omega)$
.
.
.
n	y_n	$\mu_1(n)$	...	$\mu_i(n)$	...	$\mu_i(n)$	$\mu_B(n)$

Data Handled by Fuzzy Quantification Type I

ω	Object Variable y	Fuzzy External Standard			Fuzzy Category				
		B_1	...	B_M	A_1	...	A_i	...	A_K
1	y_1	$\mu_{B_1}(1)$	...	$\mu_{B_M}(1)$	$\mu_1(1)$	...	$\mu_i(1)$	...	$\mu_i(1)$
2	y_2	$\mu_{B_1}(2)$	...	$\mu_{B_M}(2)$	$\mu_1(2)$	...	$\mu_i(2)$	...	$\mu_i(2)$
.
.
.
ω	y_ω	$\mu_{B_1}(\omega)$	...	$\mu_{B_M}(\omega)$	$\mu_1(\omega)$	...	$\mu_i(\omega)$	...	$\mu_i(\omega)$
.
.
.
n	y_n	$\mu_{B_1}(n)$	...	$\mu_{B_M}(n)$	$\mu_1(n)$	...	$\mu_i(n)$	...	$\mu_i(n)$

Data Handled by Fuzzy Quantification Type II

	Fuzzy Group B	Fuzzy Category					sum	
		1	...	i	...	K		
v_1	1	$\mu_B(1)$	$\mu_1(1)$	\dots	$\mu_i(1)$	\dots	$\mu_K(1)$	m_1
v_2	2	$\mu_B(2)$	$\mu_1(2)$	\dots	$\mu_i(2)$	\dots	$\mu_K(2)$	m_2
\cdot	\cdot	\cdot	\cdot	\cdot	\cdot	\cdot	\cdot	\cdot
\cdot	\cdot	\cdot	\cdot	\cdot	\cdot	\cdot	\cdot	\cdot
\cdot	\cdot	\cdot	\cdot	\cdot	\cdot	\cdot	\cdot	\cdot
v_ω	ω	$\mu_B(\omega)$	$\mu_1(\omega)$	\dots	$\mu_i(\omega)$	\dots	$\mu_K(\omega)$	m_ω
\cdot	\cdot	\cdot	\cdot	\cdot	\cdot	\cdot	\cdot	\cdot
\cdot	\cdot	\cdot	\cdot	\cdot	\cdot	\cdot	\cdot	\cdot
\cdot	\cdot	\cdot	\cdot	\cdot	\cdot	\cdot	\cdot	\cdot
v_n	n	$\mu_B(n)$	$\mu_1(n)$	\dots	$\mu_i(n)$	\dots	$\mu_K(n)$	m_n

$$m_\omega = \sum \mu_i(\omega) ; \omega = 1, \dots, n$$

Data Handled by Fuzzy Quantification Type III

Kind of Data	Number	Content of Data
Fuzzy Group	B₁	Favorite of sweet or not?
	B₂	Self-estimated Amount of sugar intake by child
Category Number (Fuzzy Descriptive Variable)	C₁	Believing sweet good for health
	C₁	Not believing sweet good for health
	C₄	Intake of late-night snack
	C₄	Not take late-night snack
	C₁₂	Unbalanced diet
	C₁₂	Balanced diet
	C₁₃	Demand for more snacks
	C₁₃	Not particular demand for snacks
	C₁₇	Undesirable tendency of physical state
	C₁₇	Desirable tendency of physical state
	C₁₈	Desirable tendency of psychological state
	C₁₉	Undesirable tendency of psychological state
	C₂₅	Parents' attitude of controlling meal and its time
	C₂₅	Parents' attitude of disregarding control of meal

Analysis by Quantification Types III

Application of Fuzzy Theory

[1] Applied Field

Prediction System

Measurement and Control system

Decision Making System

[2] Non-applied Field

Medical system

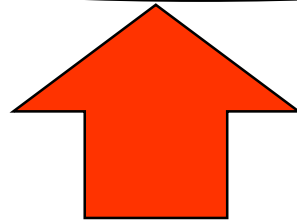
Statistical Analysis

	Correlation Coefficient
Fuzzy Quantification	0.76
Conventional Quantification	0.72

Quantification Type I

Fuzzy Quantification Type IV

Numbering of the Order of Individuals



Similarity of Individuals

Elements of Eigenvector Corresponding
to Maximum Eigenvalue

		Element					
		1	...	i	...	n	
Fuzzy Group B		$\mu_B(1)$	...	$\mu_B(1)$	...	$\mu_B(1)$
Element	1	$\mu_B(1)$	e_{11}	...	e_{1i}	...	e_{1n}
	·	·	·	·	·	·	
	·	·	·	·	·	·	
	·	·	·	·	·	·	
	·	·	·	·	·	·	
i	$\mu_B(i)$	e_{i1}	...	e_{ii}	...	e_{in}	
·	·	·	·	·	·	·	
·	·	·	·	·	·	·	
·	·	·	·	·	·	·	
n	$\mu_B(n)$	e_{n1}	...	e_{ni}	...	e_{nn}	

Data Handled by Fuzzy Quantification Type IV

Investigation by Working Group of Child and Health of Japan Society of Health Sciences

6-15 years old Children (Elementary & Middle High Schools)
Chiba, Fukui, Hokkaido, Iwate, Kanagawa, Kagoshima,
Kouchi, Shizuoka, Shiga, Wakayama and Yamaguchi

1. Data Extraction by image processing of Questionnaires
2. Construction of Database from Extracted Data
3. Trends concerning investigated items
4. Fuzzy Quantification of qualitative data
5. Mutual relation of an investigated item.

