Original Article

An experimental trial to establish risk communication as a tool to decrease the risk by exposure to multiple chemicals for the future generations

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Background: Recently, it has become clear that fetuses are exposed to multiple chemicals and environmental contaminants. However, it has been reported that allergies among young children have been increasing rapidly in the last few decades, and some congenital anomalies are also increasing. There is no evidence to connect these facts directly, however if adverse health effects are caused by environmental reasons, it could be prevented by early education or risk communication.

Methods: The authors gave lectures to students at a high school and universities, and carried out a questionnaire survey before and after the lectures to see the change of the students' knowledge, attitude and behavior. The total number of high-school students and university students was 47 and 605, respectively.

Results: It became clear that all the levels of knowledge, attitude and behavior were elevated, and they were more elevated among high school students than university students. It was suggested that risk communication at a younger age is important to elevate people's attention and motivate them, and eventually prevent their future health risk from environmental contaminants.

Conclusion: Risk communication at a young age would be more effective in increasing students' knowledge, attitude and behavior. (Reprod Med Biol 2005; 4: 65–70)

Key words: education, environmental contaminants, high-school students, risk communication, university students.

INTRODUCTION

TO UNDERSTAND THE current situation of chemical contamination of fetuses, the authors collected human umbilical cords and analyzed the chemicals in them. As a result, dioxins (polychloro-dibenzo-*p*-dioxin + polychloro-dibenzofuran + co-polychlorinated biphenyls [PCB]), PCB, *p,p'*-dichlorodiphenyltrichloroethane, *p,p'*-dichlorodiphenyldichloroethylene, hexachlorobenzene, hexachlorocyclohexane, chlordanes, endosulfan, bisphenol-A, tributyltin, heavy metals and others were detected from the umbilical cords, and phytoestrogens (estrogenic compounds derived from plants) were detected from cord serum.¹

The above study clearly showed that at least 20 chemicals and environmental contaminants were transferred from mother to fetus through the placenta, and some fetuses

were highly exposed to several chemicals.^{2,3} Recently, a concern has been spread about the health effect of multiple chemicals contaminants on children.⁴ The US National Research Council has raised the question, do the present regulatory approaches adequately protect infants and children, who may differ from adults in susceptibility and in dietary exposures to pesticide residues.⁵ The Council published a report, pointing out several unique aspects of children: (i) rapid body growth and development; (ii) the potential for relatively high exposures related to children's diet, behavior and physiologic/metabolic differences from adults; (iii) immature detoxification systems; and (iv) inadequate toxicity testing of chemicals for developmental, neurobehavioral, immunologic, and reproductive system effects of perinatal exposures.^{5,6}

Some other investigators also have shown that fetuses and young children are especially vulnerable to the toxic effects of environmental tobacco smoke, pesticides, polychlorinated biphenyls and metals.^{7–14}

There is no clear evidence to connect the multiple chemicals contamination and health effect on infants or children directly. However, in the clinical field, it has been reported

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that children's allergies have been increasing in the last 30 years worldwide, and some 45% of elementary school children now have at least one symptom of an allergy in Japan.^{15,16} Asthma has increased more than double in the last 30 years in Japan,¹⁵ and atopic dermatitis also has been increasing more than double in the last 20 years.¹⁶

In the USA, between 5% and 10% of couples desiring children have problems achieving pregnancy, approximately 35–50% of pregnancies are not successfully completed, and 3–5% of newborns have major birth defects, but the etiology of these problems is largely unknown.⁴ There is widespread concern among health professionals, environmental scientists and the public that environmental exposures may be contributing to human reproductive and developmental disorders.⁴ In 1998, the National Toxicology Program (NTP) and the National Institute of Environmental Health Sciences of the USA established the NTP Center for the Evaluation of Risks to Human Reproduction. The goal of the center was to provide scientific methods to evaluate if adverse effects on human reproduction and development may result from chemical exposures.⁴ In the USA, the Children's Health Act of 2000 was enacted, and according to the Act, the 'National Children's Study' was established. This study is led by a consortium of federal agency partners: the US Department of Health and Human Service (including the National Institute of Child Health and Human Development and the National Institute of Environmental Health Sciences, two parts of the National Institutes of Health, and the Centers for Disease Control and Prevention) and the Environmental Protection Agency.¹⁷

The authors of this present paper are concerned about the recent health problems of children, and suggested establishing new risk communication as a tool to reduce the risk for future generations.¹ In the present study, we gave lectures to university students (US) and high-school students (HS) about possible health effect of chemicals. The students were asked to answer the questionnaires before and after the lecture. Then the changes of students' knowledge, attitude and behavior after the lecture were compared and analyzed. To our knowledge, there has been no previous study of the above three aspects of environmental health education. The authors then searched for a more effective risk-communication method.

SUBJECTS AND METHODS

Subjects

FROM OCTOBER 2001 to June 2002, we gave lectures to 605 US (389 male, 213 female, 3 unknown) and 47

Table 1 Subjects of the study

	University students	High-school students	Total
Male	372	35	407
Female	210	12	222
Total	582	47	629

HS (35 male, 12 female). Seventeen questionnaires by male and three by female US were excluded from the analyses because the answers were not completed. Also, three students of unknown gender were excluded. Hence, the total number of questionnaires analyzed was 629 (582 US, 47 HS; 407 males, 222 females) (Table 1).

Study design

The lecture was for 60 min by using slides. There was a student question time after the lecture. The lecture content consisted of: human reproduction, the current situation of congenital anomalies, environmental problems/issues, endocrine disruptors, health effects of chemicals, and risk communication to decrease the risk of chemicals for the future generations. The lecturers were the researchers of these fields, and had experience in teaching students at universities. The lectures were carried out at the high schools and universities. The questionnaire survey was conducted before and after the lecture, using 10 min each (see Appendix). The questionnaire contained nine questions, asking the 'knowledge' about the problem (Q1–Q4), 'attitude' (Q5, 6), and 'behavior' to the problem (Q7–Q9). Students chose one answer from five choices for each question.

There were some changes in the questions for before and after lectures. In the questions asking about the behavior, the present tense was used before the lecture as 'Do you usually choose ...?', but after the lecture, the future tense was used as 'Will you choose ...?'.

Measures

The level of positivity or willingness elevated from answer 1–5, and the answers were given points, as answer 1 (1 point), answer 2 (2 points), answer 3 (3 points), answer 4 (4 points) and answer 5 (5 points).

Analyses of data

McNemar's test was used to see the change of the level before and after the lecture. Student's *t*-test was used to

Figure 1 The change of the levels of positivity and willingness (■) before and (■) after the lecture.

see the difference of the data between the US and HS, and male and female.

RESULTS

THE LEVEL OF all the answers elevated significantly after the lecture (Fig. 1). In each group (males, females, US, HS), the level elevated from lower level to higher level (data not shown).

The changes in answers were especially remarkable about behavior. For example, Question 7: 'Do you usually choose grocery and daily goods thinking about the effects to your health?' (average point of the answer was 2.8). However, after the lecture, the question was changed to: 'Will you choose grocery and daily goods from now on with conscious to health effects by chemicals?' (average point was elevated to 4.1) (Fig. 1).

In comparing the answers by males and females, before and after the lecture, the points by females were higher than those by males. The answers by females to the questions 4, 5, 7, 8 and 9 before the lecture (Fig. 2a), and the answers to the questions 1, 4, 5, 7 and 8 after the lecture (Fig. 2b) were significantly higher than those by males ($P < 0.05$).

Comparing the answers by US and HS before the lecture, a tendency was found that the level of the answers by HS asking about the 'knowledge' were lower than US, and the level of the 'behavior' of HS were higher than US. The answers by HS to the questions 5 and 6 were significantly lower than US ($P < 0.05$) before the lecture (Fig. 3a). However, after the lecture, the answers by HS to questions 1, 2, 3, 4, 7, 8 and 9 were significantly higher than US ($P < 0.05$) (Fig. 3b). The answers to the questions 5 and 6 by HS were higher than US, although the change was not statistically significant. It was suggested

Figure 2 Comparison between genders. (a) Average points before the lecture, (b) average points after the lecture. (■) Male, (■) female. * $P < 0.05$, versus male.

that the level of 'behavior' of HS was higher than US even before the lecture, and their willingness to act has been elevated higher after the lecture.

DISCUSSION

THIS IS THE first study to observe the effect of risk communication with respect to preventive medicine, analyzing listeners' positivity in three different categories.

Risk communication, in regard to the environmental chemical risks, is defined by the Ministry of Environment Japan as: 'Sharing precise information about environmental chemical risks, citizens, industrial parties and administration, to promote each other's understanding'.¹⁸ In risk communication, it is important to know the problem and understand the difference of other parties. Even though people do not change their opinion, they can at least understand that there is difference of opinions. Todaka *et al.* tried to establish risk communication as a

Figure 3 Comparison between (■) university students (US) and (■) high-school students (HS). (a) Average points before the lecture, (b) average points after the lecture. * $P < 0.05$, versus US.

tool to prevent adverse health effects caused by environmental chemicals or contaminants for future generations.¹ Informing the public about environmental chemical risks and benefits, human reproduction, cause-effect relationship of the environment and adverse health effect, the authors expect that people will change their behavior to a more concerned way.

According to the current research, it has become clear that knowledge, attitude and behavior of young people can be changed by risk communication. By listening to the lecture, their 'knowledge' level was elevated and their 'attitude' became more positive. Also, regarding the 'behavior', the students' positivity was increased.

Comparing the males and the females, the levels of the answers by females to all the questions were higher than males. The lecture included fetal development and the relationship between chemicals and congenital anomalies, so female students might have felt the problem more self-related than male students.

Comparing the US and HS, the levels of all the answers after the lecture by HS were significantly higher than the US, except for the two answers which were not significant. The levels of the HS before the lecture regarding knowledge and attitude levels were lower than the US, but the behavior level was higher than the US. However, all the levels of HS became higher than US after the lecture, and the behavior level, which was originally higher than US, was elevated even higher.

It was suggested that younger males/females are, more flexible and easily accept new information. Risk communication is more effective if it is performed at younger age.

It is not impossible to prevent long-term adverse health effects by education. One example was shown by the Diabetes Prevention Program Research Group.¹⁹ They divided 3234 randomly selected non-diabetics into three groups: (i) placebo; (ii) medication; and (iii) a lifestyle-modification program. The goals for the participants assigned to the lifestyle-modification program were to achieve and maintain a weight reduction of at least 7% of initial bodyweight through a healthy low-calorie, low-fat diet and to engage in physical activity of moderate intensity, such as brisk walking, for at least 150 min per week. A 16-lesson curriculum covering diet, exercise and behavior modification was designed to help the participants achieve these goals. On average, 2.8 years later, the incidence of diabetes was 11.0, 7.8, and 4.8 cases per 100 persons, for the placebo, medication and life-style groups, respectively.

Another example was published by the PREMIER Clinical Trial group.²⁰ Adults (810) with above-optimal blood pressure, including stage I hypertension, were randomized to one of three intervention groups: (i) advice only in a single 30-min individual session, no counseling on behavior; (ii) behavioral intervention, such as weight loss among those who were overweight, reduced sodium intake, increased physical activity, and limited alcohol intake among those who drank alcohol; and (iii) behavioral intervention plus dietary approach, such as increased consumption of fruits and vegetables, low-fat dairy products, reduced intake of saturated fat, and receiving instruction and counseling. The results showed the baseline hypertension prevalence of 38%, the prevalence at 6 months was 26% in the advice only group, 17% in the behavioral intervention group, and 12% in the behavior intervention plus dietary approach group. The prevalence of optimal blood pressure was 19% in the advice only group, 30% in the behavioral intervention group, and 35% in the dietary approach group.

Another example to show that early education is important to prevent future adverse health effect is the

case of antismoking programs.^{21–23} Smoking is addictive and tobacco smoke is an apparent carcinogen, and its nature is different from chemicals. However, the historical trial of antismoking programs seems to be a good example of the future treatment of chemical problems.

Smoking prevention programs are often conducted toward adults, however, it is extremely difficult to quit smoking once he/she becomes addictive to tobacco. Therefore, it has recently been said that it is important to start smoking prevention programs to children, before they start smoking.^{21–23}

It is reported that the smoking rate of adults decline significantly if the health education, including smoking prevention programs, is conducted when the subjects are elementary school pupils or junior high-school students, compared the group to whom no such program was conducted. Also, in the current study, the points of all the answers by HS became higher than the points by US after the lecture. The behavior level of HS was higher than US even before the lecture, and their willingness to act was elevated even higher after the lecture. It can be expected that people change their attitude and behavior if they receive health education at younger age.

CONCLUSION

THE CURRENT STUDY was the first attempt to observe the effect of risk communication as preventive environmental medicine, and it became clear that risk communication at younger age would be more effective to elevate students' knowledge, attitude, and behavior. However, to confirm if the effect continues, it is necessary to follow-up the students.

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Appendix I Questionnaire before and after the lecture

Questionnaire about the environment and health (*before* lecture)

Name of university (high-school): ()

Student number: () male/female

Q1: Do you know about the endocrine disruptors and dioxins?

1. I don't know at all. 2. I don't know much about it. 3. I know some. 4. I know well. 5. I know it very well.

Q2: Do you know the adverse effects to humans caused by chemicals?

1. I don't know at all. 2. I don't know much about it. 3. I know some. 4. I know well. 5. I know it very well.

Q3: Do you know that there is possibility of congenital anomalies or disease if the fetus is exposed to chemicals?

1. I don't know at all. 2. I don't know much about it. 3. I know some. 4. I know well. 5. I know it very well.

Q4: Do you know 'Risk Communication'?

1. I don't know at all. 2. I don't know much about it. 3. I know some. 4. I know well. 5. I know it very well.

Q5: Are you interested in the environmental problems?

1. I'm not interested at all. 2. I'm not interested much. 3. I'm a bit interested. 4. I'm interested. 5. I'm very much interested.

Q6: Do you think that the current countermeasures about chemicals problem are enough?

1. I think it is enough. 2. I don't think it is enough but no need to improve. 3. I think it is not enough, so it is good to change if possible. 4. I think it is not enough, so they should be changed. 5. I think it is not enough at all, so they should be totally changed.

Q7: Do you usually choose grocery and daily goods thinking about the effects to your health?

1. I don't pay any attention. 2. I don't think usually. 3. I do so occasionally. 4. I do so as much as I can. 5. I always do so.

Q8: Do you usually try to make effort to decrease the garbage?

1. I don't care at all. 2. I don't care too much. 3. I try sometimes. 4. I try to decrease it. 5. I always try to decrease it.

Q9: Are you interested in the activities to protect the environment, and actually participate in those kinds of activities?

1. I'm not interested at all. 2. I don't participate because I'm not interested much. 3. I'm interested but I don't actually participate. 4. I participate in activities sometimes. 5. I do participate in the activities with positive will.

Questionnaire about the environment and health (*after* lecture)

Name of university (high-school): ()

Student number: () male/female

Q1: Do you know about the endocrine disruptors and dioxins?

1. I don't know at all. 2. I don't know much about it. 3. I know some. 4. I know well. 5. I know it very well.

Q2: Do you know the adverse effects to humans caused by chemicals?

1. I don't know at all. 2. I don't know much about it. 3. I know some. 4. I know well. 5. I know it very well.

Q3: Do you know that there is possibility of congenital anomalies or disease if the fetus is exposed to chemicals?

1. I don't know at all. 2. I don't know much about it. 3. I know some. 4. I know well. 5. I know it very well.

Q4: Do you think that 'Risk Communication' is effective to decrease the risk of chemicals?

1. I don't think so at all. 2. I doubt it. 3. I think it is effective some. 4. I think it is effective. 5. I think it is very effective.

Q5: Are you interested in the environmental problems?

1. I'm not interested at all. 2. I'm not interested much. 3. I'm a bit interested. 4. I'm interested. 5. I'm very much interested.

Q6: Do you think that the current countermeasures about chemicals problem are enough?

1. I think it is enough. 2. I don't think it is enough but no need to improve. 3. I think it is not enough, so it is good to change if possible. 4. I think it is not enough, so they should be changed. 5. I think it is not enough at all, so they should be totally changed.

Q7: Will you choose grocery and daily goods from now on with conscious to health effects by chemicals?

1. I won't pay any attention. 2. I don't think I will care. 3. I will do so if possible. 4. I will try as much as I can. 5. I will try to do so always.

Q8: Will you try to make effort to decrease the garbage?

1. I won't pay any attention. 2. I don't think I will care. 3. I will try if possible. 4. I will try as much as I can. 5. I will try to do so always.

Q9: Will you pay attention to environmental activities and actually participate in the activities?

1. I'm not interested at all, so I won't do so. 2. I don't think I will because I'm not interested. 3. I'm interested but I don't think I will. 4. I think I will do some activities. 5. I will participate in some activities.