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Experiences of crisis communication during radiation emergency and risk communication for recovery of the community in Fukushima

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ABSTRACT

Since 2011, Nagasaki University (Nagasaki, Japan) has been assisting the reconstruction efforts of Kawauchi Village (Fukushima Prefecture), which was the first village to decide to return to their home town after the evacuation due to the accident at the Fukushima Daiichi Nuclear Power Station. In April 2013, Nagasaki University and the Kawauchi Government Office concluded an agreement concerning comprehensive cooperation toward the reconstruction of the village. Furthermore, we began comprehensive support for the residents of Tomioka who returned to their hometown in 2017, and of Ohkuma town in 2020. On the basis of the experiences in Kawauchi, Tomioka and Ohkuma, it is clear that the cooperation of residents, local authorities and specialists is essential for the recovery of areas affected by the accident at the Fukushima Daiichi Nuclear Power Station. Accumulated experiences and practices should be carefully evaluated and recorded to prepare for unexpected nuclear disasters in the future.

CRISIS COMMUNICATION IN THE EVENT OF A NUCLEAR DISASTER OR RADIATION ACCIDENT

Nuclear disasters are relatively rare events compared with natural disasters, but it is clear from the accident experience at the Fukushima Daiichi Nuclear Power Station (FDNPS), Fukushima, Japan that they can cause severe social disruption [1]. We consider that this is due in large part to the surfacing of latent fears of radiation, so it is vital to implement crisis management to address these fears. Scientists have an important role to play in this by providing nuclear disaster medical care (radiological emergency medicine) to workers exposed to high doses of radiation, but crisis communication is also essential.

Crisis communication involves communicating with local residents and communities in the event of a disaster or radiation emergency [2]. The key difference between crisis communication and ordinary risk communication is that crisis communication is directed to people facing severe disruption as a result of a nuclear disaster [2]. As in the case of the FDNPS accident, the people confronting the chaotic aftermath of the disaster were at high risk of emotional tension and severe stress—as well as mental confusion—to the point that they were unable to properly understand or remember the information they heard [3]. For this reason, it is essential to convey messages that the affected people can easily understand. As much as possible, communication should be straightforward and delivered in simple language. Explanations should be brief and accurate, without the use of specialist, scientific or complicated terminology.

After the FDNPS accident, two authors (N.T. and S.Y.) from Nagasaki University supported the radiation crisis communication efforts. On 19 March 2011, the Fukushima Prefecture Headquarters for Disaster Control entrusted them with spreading correct information on radiation health effects through crisis communication as 'advisors on radiation health risk control'. They organized crisis communication at public halls in Iwaki City on 20 March 2011 and in Fukushima City on 21 March 2011 (Fig. 1). During the communication, many questions were raised by the participants, such as 'Should we escape from Fukushima now?', 'Can we go outside without a mask?', 'Can children play outside?', 'Can my daughter have a baby in Fukushima?', 'Are radiation health effects heritable?', 'Can we drink tap water?', and 'How is the situation at the power plant now?' We noted that during crisis communication, it is crucial to convey a clear message to the public to avoid confusion.

To implement crisis communication, proper preparation during ordinary (non-emergency) times is indispensable [2]. The important

Fig. 1. Crisis communication at: Iwaki City (a) and (b) 20 March 2011; and Fuksuhima City: (c) and (d) 21 March 2011 [4].

thing is to prepare explanations on the basis of realistically conceivable scenarios and arrange answers to the questions that residents might have regarding such scenarios. In the crisis communication following the FDNPS accident, the questions posed by the residents were much the same all over Fukushima Prefecture [4]. We noticed that it is particularly important for health care workers to prepare good explanations and answers to possible questions in conceivable scenarios on the basis of the experience of Fukushima.

After the initial phase passed, risk communication regarding radiation health effects (rather than crisis communication) targeting relatively small groups became more important in Fukushima. Therefore, we began engaging in risk communication with a small group in each community and initiated a serial publication titled 'Radiation Q&A' in the local newspaper of Fukushima Prefecture to ensure the residents had a better understanding of radiation health effects [5].

RECOVERY EFFORTS FOR A NUCLEAR POWER DISASTER AND RISK COMMUNICATION

After the emergency phase of a nuclear power disaster ends, giving way to local recovery under an existing exposure situation, it is important to not only restore local infrastructure but also remove radioactive substances from local living environments (i.e. reduce exposure doses by means of decontamination). As demonstrated by the case of FDNPS, the recovery from a nuclear power disaster is unavoidably a much longer and slower process than that from other kinds of disasters. It is also necessary to deal with all the anxiety about the public health effects of radiation exposure. For this reason, an open dialog between local residents, governments and specialists of radiation medical sciences is extremely important [6].

Kawauchi Village, Fukushima Prefecture, is located within 30 km of the FDNPS (Fig. 2). After sheltering instructions were issued, almost all the residents of the village evacuated, with 75% relocating to Kōriyama City, where the Kawauchi Government Office had shifted its offices [7]. After the prime minister declared the termination of the accident in December 2011, the mayor of Kawauchi decided to return to the town.

Nagasaki University has been assisting in the recovery efforts of Kawauchi by evaluating internal and external radiation exposure doses and risk communication with the residents according to their individual doses (Fig. 3). In December 2011, we estimated the external radiation exposure doses of the residents of Kawauchi by measuring radiocesium concentrations in the soil samples collected from the residential areas of the village. The estimated external effective doses from the soil samples were 0.0011–0.38 μSv/h (0.010–3.3 mSv/y) within 20–30 km of the FDNPS. We could show that the risk of external radiation exposure of the residents was sufficiently low in Kawauchi [8].

In March 2012, the Kawauchi Village Office relocated its function to the village, and the residents started returning. In May 2012, a public health nurse from Nagasaki University stayed for an extended period

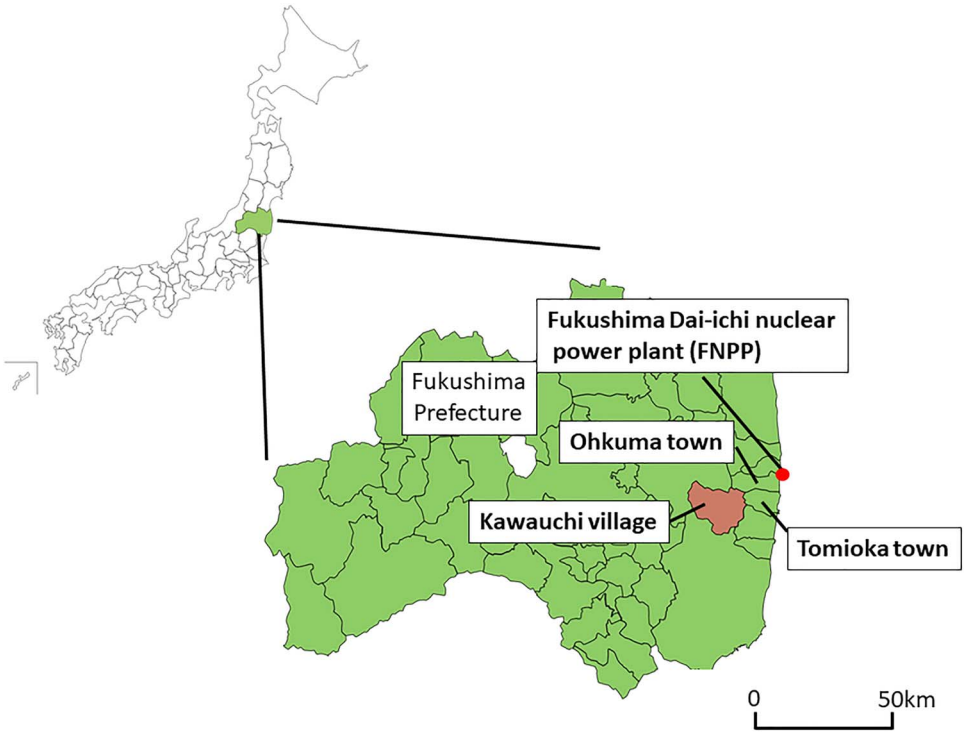

Fig. 2. Location of Kawauchi Village, Tomioka Town and Ohkuma Town.

Fig. 3. Individual consultation on radiation health effects by a public health nurse in Kawauchi Village [4].

to provide individual consultation on radiation exposure and health [6]. In April 2013, a comprehensive agreement was concluded between Nagasaki University and the Kawauchi Village Office, and a satellite office of Nagasaki University was established in the village. From this satellite office, researchers have been working with the residents and village office [6].

The town of Tomioka is located within 20 km of the FDNPS (Fig. 2). After the accident, its residents evacuated to Kawauchi, and

the town office relocated to Kōriyama. Before the accident, the total population was almost 160 000, and Tomioka played a central role in Futaba region, including Kawauchi, where the FDNPS is located.

In 2017, the evacuation order for Tomioka was partially lifted. Although decontamination efforts were complete, it was clear that most residents did not plan to return to Tomioka because many of them had already established their new lives in the places to which they evacuated. However, the recovery of Tomioka was still deemed essential for the recovery of Futaba.

To support this recovery, a comprehensive agreement was concluded between Nagasaki University and the town itself in September 2016. In April 2017, when the Tomioka Town Office reopened in the town, the university established a satellite office there and began supporting the recovery of Tomioka. Although the number of residents who have returned remains limited, it is believed that the provision of continuous support for Tomioka, based on similar experiences in Kawauchi, is important for the recovery of Futaba from the nuclear disaster.

Furthermore, Nagasaki University started the recovery support process for the town of Ohkuma, where the FDNPS has been installed since 2019 (Fig. 2). After the decontamination and re-establishment of infrastructure, the evacuation order in a part of Ohkuma was lifted in April 2019, and the town office returned there. But the number of residents who have returned to their hometown is still limited. In July 2019, the university started supporting the recovery efforts for the town through the dose evaluation of the residents, environmental monitoring, and risk communication with the residents. Similar to Kawauchi and Tomioka, a comprehensive agreement was concluded between Nagasaki University and Ohkuma in July 2020.

SCIENTIFIC EVIDENCE OBTAINED FROM THE RECOVERY SUPPORT

For the recovery of the community from a nuclear disaster, the accumulation of scientific evidence is important to organize risk communication with residents.

In March 2012, the return of residents to Kawauchi started; however, the rate of returned residents was relatively limited initially. We identified factors associated with the residents' intention to return (ITR) to the village and showed that, for female residents, living in areas with relatively higher ambient doses and expressing anxiety over radiation exposure were independently associated with their decision to not return [7]. We also identified factors associated with ITR in the residents of Tomioka and revealed that, for male residents, the anticipation of improving shopping in the town and requests for individual consultation with experts on radiation health effects were associated with their ITR. Further, living with children <18 years old, reluctance to drink tap water, and anxiety about the genetic effects of radiation in the next generation were associated with the decision to not return to Tomioka [9]. In addition, we identified factors associated with ITR in the male and female residents of Tomioka and revealed that, for both men and women, consultation requests for radiation health effects were positively associated with ITR, and anxiety about personal health effects was negatively associated with ITR. In contrast, having been born in Tomioka had a significantly positive association with ITR in male residents, whereas anxieties about drinking tap water and consuming food were negatively associated with ITR in female residents [10]. These results suggest the importance of active participation by scientists and local authorities in communicating risk to the residents involved in returning home.

In addition, we clarified the psychological status and ITR of the residents of Tomioka [11]. We investigated their intention to return home and perception of the risk of radiation health effects. We also evaluated the rates of post-traumatic stress disorder (PTSD) using a PTSD checklist (PCL-S) and psychological stress using the Patient Health Questionnaire-9 (PHQ-9). Among the residents, 102 (13%) had returned home (group 1), 214 (28%) were unsure about returning (group 2), and 450 (59%) had decided not to return (group 3). The concern about exposing the next generation to radiation was significantly more prevalent in groups 2 and 3 than in group 1. The frequency of positive PCL-S and PHQ-9 responses was higher in group 2 than in groups 1 and 3. Factors that were independently associated with the return to Tomioka included positive PCL-S and PHQ-9 scores, concerns about consuming locally sourced food and living with children, and they were more prevalent in group 2 than in group 1 [11]. The residents in group 2 were more anxious about radiation exposure and health effects and had higher rates of psychological stress and PTSD. These results suggest that careful risk communication, especially with residents who are unsure about returning to their hometown, is important for the recovery of the community.

On the other hand, the risk perception of the residents in Fukushima has been evaluated by several studies. In 2015, Suzuki *et al.* investigated the risk perception of these residents within the framework of the Fukushima Health Management Survey and reported that >40% of the residents believed delayed effects—such as cancer—would occur, and almost 60% believed that genetic effects would occur by radiation exposure due to the accident [12]. We also clarified the residents' risk perception of radiation exposure and consequent health effects in Kawauchi in 2014 and confirmed that 30% of residents felt acute radiation syndrome might develop after the accident, 54% stated having anxieties about radiation health effects on children, and 49% indicated that they had anxieties about radiation health effects on offspring. Furthermore, 37% of residents expressed concerns about the health effects that would appear in the general population simply by living in an environment with an ambient dose of 0.23 μSv/h for 1 year [the protection level for the public recommended by the International Commission of Radiological Protection (ICRP)] [13], 52% of residents reported being reluctant to eat locally produced foods, and 58% of residents believed adverse health effects would occur in the general population by consuming 100 Bq/kg of mushrooms every day for 1 year [14]. These results show that a marked bipolarization of the risk perception concerning radiation health effects among residents could have a major impact on social well-being after the FDNPS accident.

In 2017, we followed up on the risk perception study of the residents of Kawauchi and found that 38% of residents (38% in 2014) considered there would be adverse health effects from 1 mSv/y of radiation exposure. Also, 59% of the residents (58% in 2014) stated that adverse effects would occur via their annual intake of mushrooms, including 100 Bq/kg of radiocesium (the current standard value of food regulation in Japan [15]). These results suggest that the

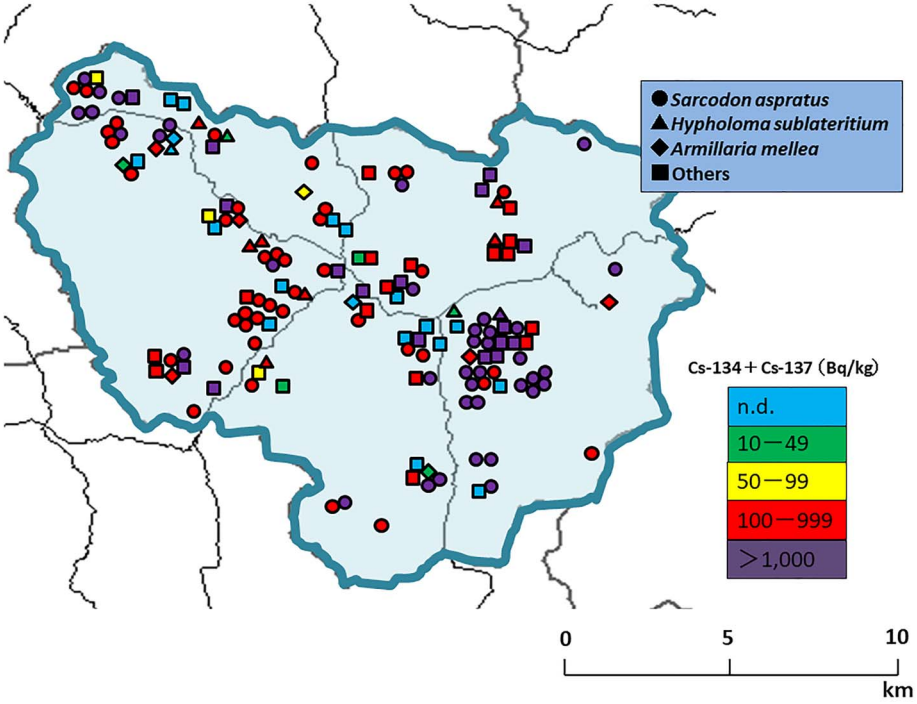

Fig. 4. 'Mushroom map' of Kawauchi Village [24].

residents do not fully understand the difference between radiation protection policy, which is as low as reasonably achievable, and the actual health effects of radiation according to the results of epidemiological studies. This gap has not changed significantly even 7 years after the accident [16].

Besides the investigation of risk perception in residents, a continuous evaluation of exposure doses of the residents is essential for effective risk communication. As described, in December 2011, we first evaluated the environmental contamination and radiation exposure dose rates because of artificial radionuclides by measuring the concentrations of artificial radionuclides in soil samples [8]. One year later, we followed up on the environmental contamination and radiation exposure dose rates in Kawauchi and showed that the levels appeared to be decreasing compared to the levels just before the return of the residents to their homes [17].

As regards the estimation of the internal exposure dose, committed effective doses from the local agricultural samples in Kawauchi collected from 1 May 2012 to 31 March 2013 were sufficiently low—in the range 18–44 μSv/year for male residents and 20–48 μSv/year for female residents (the range was 18–48 μSv/year for children and 25–43 μSv/year for adults), compared to the public dose limit (1 mSv/year; ICRP, 1991 [13])—although the potential for radiation exposure still exists [17].

Considering the experience after the 1986 accident at the Chernobyl Nuclear Power Plant, it is well known that radiocesium tends to concentrate in wild mushrooms [18–25]. On the other hand, collecting and consuming mushrooms is a part of culture for the residents in Fukushima Prefecture. We discussed with the residents of Kawauchi and decided to implement a collaboration study called the 'mushroom map project'. We asked the residents to collect mushrooms and indicate their collection spot on the map. We measured the concentration of radiocesium in mushrooms and prepared a mushroom map that included information on the type of mushroom collected, collection spots, and concentration of radiocesium in mushrooms (Fig. 4) [26, 27]. We have continued this project every autumn since 2013, communicated with each other on the basis of the results and decided the future direction of this project.

CONCLUSION

During the initial phase of a nuclear disaster, the message must be simple, short and general, with a focus on public safety via mass-gathering communication. On the other hand, after the initial phase, the topic of the communication must become more detailed and complex, with a focus on the personal content via small group/personal communication.

On the basis of the experiences in Kawauchi, Tomioka and Ohkuma, it is clear that the cooperation of residents, local authorities and specialists is essential for the recovery of areas affected by the accident at the Fukushima Daiichi Nuclear Power Station. On the other hand, we should note that many evacuees have not yet returned home in some towns/villages where similar efforts have been made. Accumulated experiences and practices should be carefully evaluated and recorded to prepare for unexpected nuclear disasters in the future. A nuclear disaster may be a relatively rare occurrence; however, once such an event happens, the disruption to local communities can be enormous. Areas hit by this kind of disaster also undergo a very long period of recovery. Therefore, it is desirable that health care workers

deal with radiation exposure-related concerns in accordance with the exposure phase (emergency exposure or existing exposure situation). Above all, the most important thing is to prepare appropriate disaster responses during ordinary (non-emergency) times.

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REFERENCES

1. International Atomic Energy Agency (IAEA). *The Fukushima Daiichi Accident*. Available at http://www-pub.iaea.org/books/IAEABooks/10962/The-Fukushima-Daiichi-Accident [Accessed on 3 December 2015]
2. United States Environmental Protection Agency. Communicating radiation risks: Crisis communications for emergency responders. https://www.epa.gov/sites/production/files/2017-07/documents/epa_communicating_radiation_risks.pdf (Acccessed 17 November 2020).
3. Yamashita J, Shigemura J. The great East Japan earthquake, tsunami, and Fukushima Daiichi nuclear power plant accident: A triple disaster affecting the mental health of the country. *Psychiatr Clin North Am* 2013;36:351–70.
4. Takamura N, Taira Y, Yoshida K et al. Communicating radiation risk to the population of Fukushima. *Radiat Prot Dosimetry.* 2016;171:23–6.
5. Takamura N. *Radiation Q&A*. 2016: https://www-sdc.med.nagasaki-u.ac.jp/abdi/publicity/data/radiation-qa_e.pdf (Accessed 10 August 2020).
6. Takamura N, Orita M, Yamashita S et al. After Fukushima: Collaboration model. *Science.* 2016;352:666.
7. Orita M, Hayashida N, Urata H et al. Determinants of the return to hometowns after the accident at Fukushima Dai-ichi nuclear power plant: A case study for the village of Kawauchi. *Radiat Prot Dosimetry.* 2013;156:383–5.
8. Taira Y, Hayashida N, Orita M et al. Evaluation of environmental contamination and estimated exposure doses after residents return home in Kawauchi Village. *Fukushima Prefecture. Environ Sci Technol.* 2014;48:4556–63.
9. Matsunaga H, Orita M, Iyama K et al. Intention to return to the town of Tomioka in residents 7 years after the accident at Fukushima Daiichi nuclear Power Station: A cross-sectional study. *J Radiat Res.* 2019;60:51–8.
10. Matsunaga H, Orita M, Taira Y et al. Intention to return in residents of Tomioka, Fukushima prefecture, Japan stratified by sex after the accident at Fukushima Daiichi nuclear Power Station. *Prehosp Disaster Med.* 2020;35:235–6.
11. Orita M, Mori K, Taira Y et al. Psychological health status among former residents of Tomioka, Fukushima prefecture and their intention to return 8 years after the disaster at Fukushima Daiichi nuclear power plant. *J Neural Transm (Vienna)* 2020;127:1449–54.
12. Suzuki Y, Yabe H, Yasumura S et al. Psychological distress and the perception of radiation risks: The Fukushima health management survey. *Bull World Health Organ.* 2015;93:598–605.
13. International Commission of the Radiological Protection (ICRP). 1990 recommendations of the international commission on radiological protection. ICRP publication 60. *Ann. ICRP* 1991;21:44–6.
14. Orita M, Hayashida N, Nakayama Y et al. Bipolarization of risk perception about the health effects of radiation in residents after the accident at Fukushima nuclear power plant. *PLoS One.* 2015;10:e0129227.
15. United Nations Scientific Committee on the Effects of Atomic Radiation. Sources, Effects and Risks of Ionizing Radiation; UNSCEAR. *Reports to the General Assembly with Scientific Annexes; United Nations*. New York, NY: USA, 2013, 2014.
16. Sato N, Orita M, Taira Y et al. Seven years post-Fukushima: Overcoming the resident-specialist gap. *J Radiat Res.* 2018;59:526–7.
17. Taira Y, Hayashida N, Orita M et al. Evaluation of environmental contamination and estimated exposure doses after residents return home in Kawauchi Village. *Fukushima Prefecture. Environ Sci Technol.* 2014;48:4556–63.
18. Skuterud L, Travnikova IG, Balonov MI et al. Contribution of fungi to radiocesium intake by rural populations in Russia. *Science of the Total Environment* 1997;193:237–42.
19. Jesko T, Zvonova I, Balonov M et al. Age-dependent dynamics of cesium radionuclide content in inhabitants of the Bryansk region, Russia: A seven-year study. *Radiation Protection Dosimetry* 2000;89:179–82.
20. Hille R, Hill P, Heinemann K et al. Current development of the human and environmental contamination in the Bryansk-Gomel spot after the Chernobyl accident. *Radiation and Environmental Biophysics* 2000;39:99–109.
21. Hoshi M, Konstantinov YO, Evdeeva TY et al. Radiocesium in children residing in the western districts of the Bryansk oblast from 1991-1996. *Health Physics* 2000;79:182–6.
22. Travnikova IG, Bruk GJ, Shutov VN et al. Contribution of different foodstuffs to the internal exposure of rural inhabitants in Russia after the Chernobyl accident. *Radiation Protection Dosimetry* 2001;93:331–9.
23. Sekitani Y, Hayashida N, Karevskaya IV et al. Evaluation of ^{137}Cs body burden in inhabitants of Bryansk oblast, Russian Federation, where a high incidence of thyroid cancer was observed after the accident at the Chernobyl nuclear power plant. *Radiation Protection Dosimetry* 2010;141:36–42.
24. Guillén J, Baeza A. Radioactivity in mushrooms: A health hazard? *Food Chemistry* 2014;154:14–25.
25. Orita M, Kimura Y, Taira Y et al. Activities concentration of radiocesium in wild mushroom collected in Ukraine 30 years after the Chernobyl power plant accident. *PeerJ.* 2018;6:e4222.
26. Nakashima K, Orita M, Fukuda N et al. Radiocesium concentrations in wild mushrooms collected in Kawauchi Village after the accident at the Fukushima Daiichi nuclear power plant. *PeerJ.* 2015;3:e1427.
27. Orita M, Nakashima K, Taira Y et al. Radiocesium concentrations in wild mushrooms after the accident at the Fukushima Daiichi nuclear Power Station: Follow-up study in Kawauchi village. *Sci Rep.* 2017;7:6744.