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Risk, uncertainty and medical practice: changes in the medical professions following disaster

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Risk and uncertainty can destabilise and reconstruct the relationships between medicine, policy and publics. Through semi-structured interviews with medical staff following the Fukushima 3.11 Disaster, this paper demonstrates the way in which disruption (caused by disaster), coupled with uncertainty (in this case, around radiation risk) can serve to transform medical practices. After Fukushima, a deficit in publicly-trusted approaches to disaster management meant that the role and status of key medical professionals was transformed. This reorganisation of medical work included the development of new forms of expertise, the stretching of expertise beyond previously well-defined professional boundaries, and shifts in the way in which medical professionals understand and interact with publics. These changes signified the rise of new relationships between the medical workers and their community, as well as adjustments in what were regarded as the boundaries of medical work. Given both the ubiquitous threat of disasters and calls for increased engagement between the medicine and the public, this case study provides insight into the forms which such engagements can take, especially when bound by conditions of uncertainty. The paper draws upon the theoretical literature around the impact of uncertainty on policy, and combines this with medical sociological literature on the nature of medical expertise. The paper examines the shifting of medical expertise towards mode 2 forms, and evidences the impact of a democratised science of risk on the roles and functions of medical practice.

key words risk • Fukushima • medical professionals • expertise

key messages
- Uncertainty following disaster results in the production of new forms of expert practice
- Radiation risks in this case study produced the collection of novel evidence
- These practices emerged in response to community uncertainties
- This produced new roles for medical practitioners within their community

Introduction

This study investigates the impact of the Fukushima 3.11 Disaster on the expertise and evidence-generating practices of medical professionals in a directly-affected region. Following the disaster, public fear around radiation exposure was coupled with distrust in the central government (Tateno and Yokoyama, 2013; Feldhoff, 2018). The government was perceived by the general public to have misrepresented risk, miscommunicated the extent of exposure, and mismanaged public safety during the acute phase of the disaster (Figueroa, 2013; Miller, 2016). Under these conditions, as this paper will demonstrate, medical doctors in the region began to undertake the collection and communication of evidence around local radiation exposure. In doing so, the structure of their work has shifted, in particular through the expansion of expertise (field of socially-sanctioned knowledge) and practice (field of professional duties). This case study therefore reflects on the potential role of medical professionals in wider community (rather than patient) engagement, and the broadening of medical expertise as a response to the disaster and attendant politics of risk communication.

This case study articulates the changes in medical expertise and practice that occur at the microsociological level under conditions of risk and uncertainty precipitated by disaster. Medical expertise is understood as the professional claim to exclusive knowledge around health, illness and the body (Freidson, 1988; Willis, 1990; Coburn and Willis, 2000), which serves as the basis for medical professional power (Abbott, 1988). Maintaining monopoly over biomedical knowledge is generally described as crucial to enduring professional power (Freidson, 1970), which is underpinned by claims to exclusive expertise around specifically biomedical aspects of disease. 'Risk' is referred to through the tradition of constructivist sociologies (Beck, 1992; Bauman, 1999; van Loon, 2013), conceptualising risk – the potentiality of future harm – as a product of the contemporary organisation of society which is socially perceived, constructed and acted upon (such that the constructions of risk, rather than objective measurement, form the key basis of social action). Risky phenomena (here, the effect of radiation following the disaster) are novel, complex, variable and by definition ill-understood (Nowotny, 2003; Miller, 2004). 'Uncertainty' refers to the unknown element of risks, where (aspects of) risk are socially perceived to be unknowable, and where these unknowings are underpinned by evidence that is speculative (based upon limited or emerging data or on modelling) (Funtowicz and Ravetz, 1993). One of the ways in which medical practices changed following the disaster was in the rise of new evidence-generating practices – collecting data to demonstrate and articulate rates of radiation exposure – used to understand the risk caused by radiation release. The case study demonstrates the way in which risk and uncertainty underpin changes in medical expertise and practice following a primarily non-medical disaster.

The knowledge and practice of medical doctors is generally understood within the health sociology to be underpinned by classical models of expertise, where medical professionals are socialised and accredited through medical education (Reuschemeyer,

1983). Medical knowledge is produced through the maintenance and policing of jurisdictions with neighbouring medical para-professions, where claims to expertise are made over defined areas of practice (Freidson, 1988; Willis, 1990). This monopoly over knowledge and practice is key to professional definition, training, and work. In effect, medical status is traditionally underpinned by a strong but narrow field of expertise. The relationship between medical knowledge around uncertainty is particular, and mirrors classical forms of expert knowledge. As Groopman (2007: 7) asserts 'medicine is, at its core, an uncertain science'. Despite (or perhaps because of) this, medical expertise tends to approach uncertainty as a condition to be avoided; the most effective way in which to deal with uncertainty is to disguise, deny or deflect it (as Lingard et al's (2003) study of professional practices and socialisation suggests). These actions maintain control over a fundamentally uncertain situation (Hall, 2002). Medical education and socialisation encourage doctors, where possible, to ameliorate uncertainty, which generally occurs through the process of diagnosis (Fox, 2000; Hall, 2002). However, in the context of the Fukushima 3.11 Disaster, medical professionals were directly confronted with conditions of uncertainty outwith the classical medical purview.

As with other forms of institutional change (Djelic, 2010; Hall, 2010), exogenous shocks to a stable system can potentially present a route into changing medical professional practice. Within the health sociology literature, key exogenous factors known to have influenced medical practice include: the increasing regulatory role of the state (Germov, 2005; Dent, 2006); the changing impact of technology (Timmermans and Berg, 2003); the rise of para-professional groups (Weiss and Sutton, 2009); and the rise of lay expertise (Fox et al, 2005; Wilson et al, 2007). These literatures all focus on ways in which societal and political transformations result in the narrowing of medical expertise and/or the narrowing of the field of medical practice. In contrast, the case study of Fukushima presents a different mechanism through which medical expertise can be transformed. Here, the exogenous shock of the disaster – which both changed the patient community and destabilised medical care – was coupled with shifts in professional motivation and positioning to allow local doctors to socially define issues of post-disaster medical risk. In analysing this case study, it will be shown that the medical professionals of Fukushima moved from classical/normal forms of medical expertise, as described above, to post-normal forms of expertise.

While medical expertise is generally understood (through the medical sociology literature) as characterised by classical forms of expertise, this expertise can develop beyond these moulds, as is explicable through the sociology of science literature on mode-2 expertise. The theory of mode-2 expertise focuses on the contemporary structuring of science (and its relationship to policy) and how this can be different from past practices (Nowotny, 2003; Jasanoff, 2004b). Looking at areas where expertise and policy became closely integrated (in particular around climate change and other aspects of environmental policy), the concept of mode-2 science argues that the previous institutionalisation of science sets it apart from the rest of society as an autonomous rational authority (that is, normal science) (Kuhn, 1970). Here, scientists were able to develop their disciplinary fields without the interference of external perspectives, where the questions of scientific endeavour were the questions of scientists themselves. This resonates with classical medical expertise, where medical knowledge is exercised around issues of biomedical (dys)function. The contemporary, post-normal, organisation of science represents an important departure from this past structuring (von Schomberg, 1993; Funtowicz and Ravetz, 1994; Nowotny et al, 2001; Jasanoff, 2004a), in that

scientists must negotiate their research with other social institutions, and work on research problems that arise out of society, rather than discipline-bound perspectives. This involves the production of strongly contextualised science where: uncertainty is part of the research problem; there is a need to interact with non-scientists; and, people or the results of social action are part of the research problem (see Nowotny et al, 2001). Arguably, such science also carries greater prestige, public exposure and social impact (Funtowicz and Ravetz, 1993; Shrader-Frechette, 1993). This is linked to the 'democratisation' of science, where the outputs of scientific research must be utilised in a way that is transparent to citizens, and the public must be persuaded of the collective benefits of these efforts (Nowotny et al, 2001; Jasanoff, 2004b).

This paper demonstrates that the Fukushima 3.11 disaster resulted in a renegotiation of the role of medical professionals in this region. It argues that, in this case, medical expertise has been broadened to more closely resemble forms of mode-2 expertise. Conditions of risk (the release of radioactive materials and post-disaster institutional instability) were coupled with public uncertainty around radiation measurement and trust in the government as a site of collecting and communicating evidence around the release of radiation. Medical professionals began to take a role of leadership in the collection and communication of evidence surrounding risk to the local public, and thus established new patterns of expertise. The case shows that the shift towards mode-2 expertise is not only visible in the macro-structural relations between science and society but can also be produced at the level of the relationship between the professions and their communities.

The case of the 3.11 disaster

The Great East Japan earthquake caused significant damage to inhabitants and dwellings. The off-shore epicentre precipitated a series of tsunami waves – travelling as far as 10km inland – along the east coast of Japan, causing most of the nearly 20,000 recorded deaths (Nakahara and Ichikawa, 2013). A further consequence was damage to the Fukushima Daiichi nuclear power plant, resulting in the release of radioactive materials.

This paper focuses upon the work of practitioners within health institutions across Minamisoma, a city with a 'centre' approximately 25km from the Daiichi plant, with (at the time of the disaster) a relatively small population of approximately 71,000 (Zhang et al, 2014). Minamisoma is the closest regional centre to the Daiichi plant and is placed across all three evacuation zones (Hasagawa, 2013) (please refer to Figure 1). The health institutions studied here were all within 30km of the power plant, and represent some of the closest functional medical sites to the nuclear disaster.

Methods

Data collection and analysis

This article draws upon interviews with staff from five health institutions across Minamisoma. This study sampled staff who were involved in medical work at both the time of the disaster and at the time of interviewing, five years post-disaster. This resulted in interviews with 35 medical staff who had been working at the

Figure 1: Field site, showing positioning within initial government evacuation zones
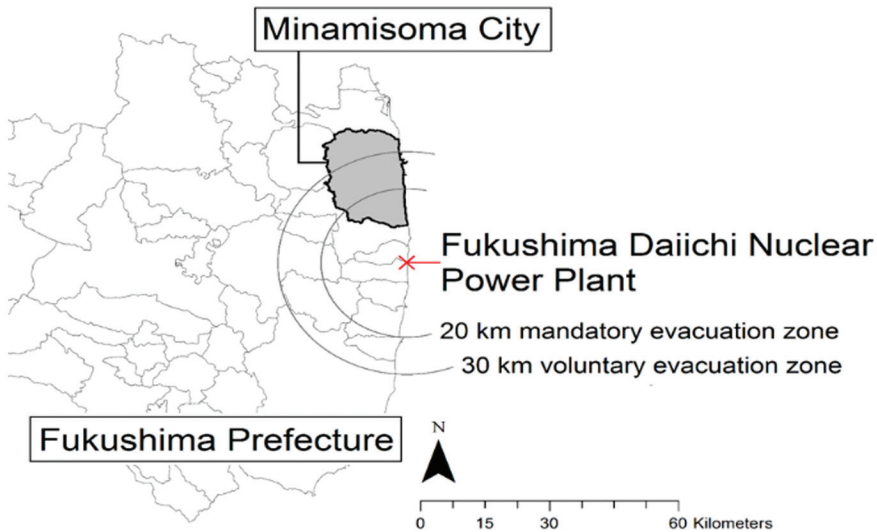
point of the 3.11 disaster, including doctors, nurses, allied health professionals, medical technicians, and administrative/support staff. The interviewees were enlisted by Ozaki, through a combination of formal recruitment (emails and personal communications), snowballing from an initial sample, and through gatekeepers. Ethics approval was granted by the committee of Minamisoma General Municipal Hospital (case number 28-6) and the School of Social and Political Science, University of Edinburgh.

Interviews followed a semi-structured approach (Silverman, 2013) and ranged from 45 minutes to 2 hours and 20 minutes. The questions generally prompted the interviewees to provide a semi-chronological account of their experiences. Each interview was conducted in Japanese with interpretation between the English-speaking primary interviewer (Abeysinghe) and the interviewees. Interpretation was provided by Leppold, Ozaki and Morita, with at least two interpreters being present at each interview to provide real-time checking. Where needed, transcripts were also checked to pick up additional translation issues prior to coding of interview data. Interviews were conducted by Abeysinghe, apart from one small-group interview of four medical technicians, who agreed to be interviewed only on the condition that they do so together. This was conducted by Ozaki and subsequently translated.

The data was analysed using a broad thematic analysis (Braun and Clarke, 2013), focusing on explicit narratives and key themes produced by the interviews. This approach allowed for an in-depth understanding of the experiences of medical staff following the disaster. It is important to note that the timing of the interviews (five years post-disaster) means that the interviews are necessarily based upon (sometimes unreliable) memory and recollection. However, the themes explored in this article remain a sustained part of medical practice in the region, and therefore the results being reported in this paper are unlikely to be affected by issues of mis-memory.

Results

Radiation uncertainty and the new role of the hospital

Radiation exposure became a key public concern following Fukushima. This is underpinned by uncertainty, given the public distrust of official sources of evidence surrounding radiation contamination. This has resulted in a multiplicity of data collection methods surrounding this risk (including through citizen science, as investigated by Brown et al, 2016; Kimura, 2016). This public distrust of official data around risk is borne out in many representations (for example, Glionna, 2011; Hino, 2017) and reflections (Figueroa, 2013; Ho et al, 2013) of the community during the acute disaster and immediate post-disaster reconstruction. Distrust of government narratives was also clear in the interviews conducted for this study. Interviewees noted the chaotic nature of early information about the Daiichi power plant's radiation leak, and also expressed scepticism about the veracity of government accounts around the extent of radiation or the harm caused by radiation exposure. In this quote, an interviewee reflects this common refrain:

> The government even says that the first [radiation] measurements that they took have gone somewhere [i.e. disappeared]. That something has happened to them. They just don't know where the measurements are. And I really think that cannot be true. I guess if they would just tell us the way things really are, that would be good. But this feeling that things are being hidden is a source of anxiety. Even now I have a radiation device myself. (Doctor)

The last line of the quote – that this interviewee, six years later, uses a personal radiation device – is indicative of both the distrust of official measurements and individual and local attempts to alleviate uncertainty around radiation measurement.

This uncertainty was bound by a lack of evidence regarding the extent of radiation exposure faced by the community. As one doctor put it, '… many people were suffering from fear of the powerplant accident and the impact of this on our bodies. So, we had no data and no knowledge about the effect of radioactive exposure on our bodies'. The uncertainty was linked to public fears about the potential health impacts, the general safety of the community, and the continued (in)stability of the nuclear reactors:

> Well honestly, even now, I still feel that way. I'm uncertain about whether anything will happen again [to the powerplant]. And it's not just me but also other staff members. And sometimes we will have these conversations… I guess, in the long term, it's continued to this day. (Nurse)

Under these conditions there was a clear gap between expertise and information, as information around the effects of the nuclear aspects of the disaster was unclear and/or untrusted. This created space for the rise of alternate forms of expertise (moving beyond normal medical work) and evidence making, which over time became filled by the work of particular medical staff in the region.

In addition to the rise in the use of personal radiation monitoring devices, institutionalised changes occurred in the positioning of medical care. In response to the dearth of clear data, medical institutions, in interactions with the public, became

the recognised source where reliable data regarding radiation could be obtained. This positioning reframed the role of medical work within this community:

> So the government was lying. But the hospital had remained. And the hospital had always been remaining here, and having some interaction with the residents. I think there was some degree of trust with the measurements that were taken in the hospital. The people from inside and around this area had felt like the government was lying. But they believed that the hospital was telling the truth. (Radiologist)

This set the stage for the changing role of medical professionals. The distrust in government-collected and -communicated data meant that the medical workers responded to community-based initiatives (such as mothers' groups and evacuees' groups) and community frustrations to become a key site for information and expertise. This is reflected in the changing relationship between the medical professionals and the community and also in changed roles and functions of individual medical professionals.

Developing new expertise

The shared understanding between the community and the hospitals about the lack of effective and trusted data around radiation – where members of the public were asking health-care workers for advice about radiation but practitioners were not trained to respond to these queries – resulted in medical practitioners reorienting their work practices to cope with the new goals of the hospital in providing evidence around radiation rates and communicating the potential and measured impact of the disaster on health.

For individual medical professionals this meant developing areas of expertise outwith their professional training. For example, the focus on radiation resulted in a need for radiation specialists, a form of expert practice that was not present in the medical community prior to the disaster. One doctor describes the process of becoming an expert on the effects of radiation:

> I found that many young mothers were anxious about radiation. I was a haematologist, so I didn't have much knowledge of radiation. I was not a specialist in radiology… but I knew a little bit about radiation. I talked to young mothers about the little knowledge about radiation. Saying 'radiation is something like light, that it's emitted from radioactive materials'… or something like that. So, these mothers were very happy to get information about radiation, even if my knowledge level was very limited.
> Soon after that [on request from both community groups and city office officials] I had to give radiation lectures to all [City] students, or all [City] residents. Maybe, 15 times or 20 times. Mmmm. So, I learned a lot about radiation, within a week, and made slides, and gave these lectures. (Doctor)

This individual development of expertise reflected wider changes in the forms of knowledge which the medical professionals were expected to possess and convey.

Specialist and general medical training assert a practice of expertise that is focused on the (relatively narrow) dysfunctions of the body and corresponding methods of biomedical treatment (Freidson, 1970; Willis, 1990; Coburn and Willis, 2000). This mirrors the classical (or, in Kuhn's (1970 terms, normal) model of expertise, where professional education socialises the doctor into the paradigm and practice of his or her specialism. In contrast the development of expertise that occurred after the disaster, as illustrated in the quote above, reflects a different – post-normal – model of expertise (Funtowicz and Ravetz, 1994; Nowotny et al, 2001; Jasanoff, 2004a). Medical professionals were motivated by the questions of the community, reflecting the conditions of expertise that are more commonly attributed to scientists in discussions of post-normal science and mode-2 science. This included the fact that these shifts in expert knowledge were precipitated by uncertain risks, focused on questions that arise outside the profession itself, and were linked to pressing policy questions (Nowotny et al, 2001).

In other medical professional categories, there were also shorter-term examples of this expansion of expertise. For example, during the acute phase of the disaster and the immediate aftermath, technical staff had to develop new forms of expertise around radiation monitoring. Many professionals were harnessed into radiation testing in the immediate post-disaster period:

> … we received a machine that no-one had actually tried to use for measurements [as this would only be used in disaster situations]. What we realized was that radiation was going to become a problem in this area and we needed a machine, that was the only thing available to us. But then even if you tried to use it the results wouldn't be accurate. [We thought] [m]aybe this is because there is cesium around it. There was no [experimental] control, to understand what effect that [environmental] cesium had. It works well if there is no background [contaminants], but of course there is cesium, so… We tried to make it into an environment where you could accurately measure the levels there. (Technician)

The rise of this work was a direct function of community pressure. The nature of work was also modified to appease community reactions to the testing results:

> … many people wanted to be screened. So, telephone calls were running all the time. And we decided not to talk with all residents [who had been tested] and just handed the results. So we could screen patients, more than 100 patients a week or something. But after that we got some… we got many, many complaints from participants. Saying that we 'cannot understand the results', or 'we cannot make sense' or something. Talking with residents was quite tough, but talking with residents was better. (Doctor)

Such work required these professionals to suspend routine medical work to focus on the immediate problem of radiation monitoring, and in so doing to create new informal practices of carrying out this work.

Another example of this short-term refocusing of medical work is seen in the case of technical workers who were asked to perform cause of death certification of people who had died in the radiation exclusion zone:

> … at times when the level of radiation was high, we would do everything
> that we could to clean up the bodies and to reduce the levels of radiation.
> We would try to get the radiation down to some type of border-line level,
> where the bodies could then be sent out. So, we were washing the bodies and
> making them cleaner and then measuring it again. There were so many things
> that needed to have the radiation levels monitored and the contamination
> levels checked. (Technician)

These activities reflected essential medical duties and the temporary displacement of
work tasks following the disaster. Yet, such activities were transient in nature, rather
than sustained or routinised changes. However, as with the new forms of expertise
around radiation and community engagement, such as public lectures and new
measurement techniques, these forms of work did result in the production of new
forms of medical practice linked to the disaster.

The stretching of expertise and rise of new forms of medical evidence

Following the disaster, the medical sites started to collect various forms of individual
and community-level data, which included the production of new classificatory
systems to make sense of these novel sources of data. This included new internal
radiation measurement activities and place-based mapping of radiation. Other new
classificatory processes were directly related to morbidity and mortality caused by
the disaster. Interviewees involved in producing death certifications, for example,
reflected on the fact that they were obligated to create new classificatory systems in
undertaking this task (noting that such work was not part of the pre-disaster activities
of these professions):

> We had to come up with lots of different ways of measuring and classifying.
> Figuring out how to summarise the radiation on their bodies and the
> radiation in the cars they had been in, and everything. We were actually the
> first people to go in there and to do this. And I was coming up with these
> different ways of classifying the information. (Technician)

Such transient practices of data collection were the result of the conditions of the
disaster itself, and can be understood at least in part as a simple extension of the
work of medical professionals (for example, see Busuttil and Jones, 1992 on autopsy
following disasters). However, the 3.11 disaster also resulted in completely novel forms
of generating new evidence, due to the uncertainty around radiation exposure. These
new practices and forms of evidence have persisted over time.

The disaster prompted doctors and health-care managers to collect population
and area-level data to better quantify environmental radiation exposure rates. This
included radiation maps which denoted the spread of radiation across the city (since
radiation is not equally distributed, it can vary widely even within a small area). Here,
a participant notes how this new practice was linked with the uncertainty surrounding
radiation exposure:

> I couldn't say anything in… with confidence. Because I didn't have actual
> data; I didn't have… I didn't perform any measurement. So, I tried to go

outside the hospital, especially to schools, high schools and junior high schools, to make radiation maps. So I went to one junior high school with [another doctor]. And measured many places and made a map. And I handed it over to the school teachers. (Doctor)

Part of the role of doctors became making sense of, and transmitting information about, such maps. The medical professions were therefore directly involved in producing new practices of knowing about radiation exposure, working directly among (and distributing the products of this work directly to) the community.

In reacting to the needs and fears of the community (as perceived through community requests for further information), such professionals were also – again, unusually – involved in the rise of new medical technologies. Following the disaster, internal radiation testing of citizens became an important function of the hospital. Though the number of these patients presenting for testing has been decreasing steadily over time, measuring internal radiation of citizens remains an important role. One technician explains the practice:

Well, if you look at this area, while there was radiation here, there wasn't that much. [But] [i]f you say [to a patient] that there is no radiation, that's not good either. So [doctor x] and I really tried to find some way to measure this. And the machines we have now, even if there is a little bit of [internal] radiation we can measure it. (Technician)

This form of practitioner engagement in the development and use of new technologies disrupts standard patterns of creation and rollout. Such activities are indicative of the new forms of expertise found following the disaster, and the broadening of the expert role in this context.

One novel technology co-produced by doctors, scientists and technologists as a result of the disaster was a device for testing the internal radiation of infants and small children. This device was developed due to the specific requests from community members around the testing of children:

They were always people asking us 'please measure my children too'. But really that machine can only accurately measure adults. We always said 'we cannot measure them'. And that turned into quite a difficulty.

… we were trying to measure radiation in family units. But of course, there were people [patients] who wouldn't believe those results either. For those people with those opinions, they were the ones [who were] really strongly telling us to measure things. And then we were eventually able to develop the BabyScan…. It's something that we made – including [a physicist] – it's something that we made by ourselves. It's not a machine that had existed before. (Technician)

In this way the medical profession became a locus of new expertise and evidence collection around the radiation-related aspects of this disaster. This represented a significant stretching of the role of the medical professions, the production of novel practices of collecting and classifying evidence around the disaster, and a stronger and more direct engagement with the local community.

Medical expertise beyond the hospital

There has been a global push for medical professionalism to include a closer engagement with policy and social justice activities (Medical Professionalism Project, 2002; Huddle, 2011; Tilburt, 2014). This call for socially-engaged doctors has prompted debates around the nature and boundaries of expertise (Croft et al, 2012; Huddle, 2014) and the rightful role of medical professionals in influencing and advocating within policy and public processes. In general, these discussions have been focused on professional ethics, examine issues around resource distribution and equity within health systems, and come as calls from within the medical profession itself. There is a dearth of empirical evidence around how such activities can shape the practices and roles of medical professionals at the level of individual doctors.

When looking at the impact of the 3.11 disaster on the medical professions, it is clear that many doctors and para-professionals did reflect on changing relationships with the local community. One surgeon, for example, cites his experiences during and following the disaster as precipitating a new interest in primary care:

> I think before the disaster, medical care was just… you would go from your home and you would go to the hospital and you would do surgeries, ward visits, or out-patient work. But after the disaster happened, I think we have started thinking about what it is that the hospital actually needs to do to help the residents and the citizens here. (Doctor)

These shifts are also reflected at the managerial level, where the practice of the hospital itself has been reframed in reference to the changing needs of a community that is faced with accelerated ageing, and higher rates of social isolation and insecurity:

> I guess if I think about what has changed. Before the disaster, we really just saw patients who came to the hospital. But after the disaster… [the Hospital Vice-Director] started going to the temporary housing places and [a surgeon] has started teaching men carpentry workshops…. (Hospital Manager)

One of the consequences of the disaster has therefore been a transformation in the relationship between the medical sites and the communities that they serve.

In effect, the disaster has served to strengthen links between medical work and the community. As health-care institutions became a site of legitimate information around radiation risk, the work of individual practitioners became mobilised around risk communication:

> Of course, I do work treating patients in the out-patient department, but my main job is to talk with City Office people, talk with the residents, talk with the schoolteachers. To make connections between the hospital and the people. (Doctor)

As such, the 3.11 disaster also resulted in strengthening links between the medical profession and both the community and local policy makers. It is also notable that the doctors in this region developed engagement with the media, locally, nationally and internationally (see for example Aoko, 2013; Woo, 2015). These new roles enshrine a broader form of expertise, where these professionals have moved beyond the traditional

boundaries of medical practice into practices of creating and disseminating new forms of evidence around risk.

Links between professional status and the expansion of expertise

There are many potentially positive impacts of the expansion of medical expertise, both for the community and for the practitioners themselves, who tended to report a sense of satisfaction in their more community-faced roles. However, it is important to also briefly situate these changes within the wider structures of these medical institutions.

These sites are engaging in new and more varied forms of medical practice, which include new forms of medical testing in addition to responsibilities around communicating with the public and policy makers. These more positive aspects tended to be expressed by high-status medical professionals within the interviews (doctors, as well as managers and para-professionals in positions of seniority). While other categories of professionals have also experienced changed roles, this is more likely to be reported in terms of a displacement of focus or expertise. For example, here we see a medical technician reflecting on the impact of radiation testing:

> At the time they told me that my job might partially involve the Whole Body Counters [which monitor internal radiation]. But when I started actually working here it seemed like my job was entirely on the Whole Body Counters. I didn't like that. I objected to it and told them 'this is not my job'. (Technician)

The routinisation of radiation testing (as opposed to the development of new tools for testing, or the development of new classificatory processes) has therefore resulted in deprofessionalisation.

While doctors reflect on the broadening of their expertise and agentic shifts into new areas of specialism (for example, surgical to home care, as in the case above), nurses and other paraprofessionals narrate changes in medical work in more negative terms. The shortage of nurses following the disaster resulted in shifts in workload:

> … well the workload has increased. The amount of work, and also the contents of the work, has changed over time slowly. So for example, there were four people for the night shift per night, but now there is only three. And they started shifting people around, across different [specialty-based] floors as well. (Nurse)

In contrast to doctors, some paraprofessionals experienced a narrowing of expertise following the disaster. In this quote, a doctor reflects on the limitations placed on his partner, a hospital-based pharmacologist:

> … when we argue about things, she always says 'well this is so good for you. You get to do the things that you want to do, but I'm just sitting here handing out medicines, and I can't do the difficult parts of pharmacology work that I would like to do'. (Doctor)

While there are clear patterns in the broadening of medical expertise following the disaster, these examples suggest that this may have been coupled with a redistribution of work, with increases in workload and narrowing of expertise and practice for other categories of medical worker. These changes are important to acknowledge when considering changes in professional practice as a whole.

Discussion

The Fukushima 3.11 disaster resulted in the restructuring of medical work in the region, and this continues to affect the practices and experiences of individual workers.

Once risk has entered the social consciousness it necessitates action. Simultaneously, established patterns of evidence collection do not exist (Nowotny et al, 2001; Nowotny, 2003). Conditions of risk and uncertainty therefore can problematise the actions of previously trusted institutions. Mistrust can be highlighted or exacerbated by changing accounts of risk, or (perceived) uncertainty around the data that underpins risk assessment (Abeysinghe, 2014). Under such conditions, the authority of institutions – or the relative power of different institutions and actors – can shift.

Community mistrust in the government was contrasted with the trust held in the hospital, as medical professionals had been physically present during the acute phase of the disaster and were perceived as a repository of objective information about health and illness. At the same time, the impact of the disaster on medical sites meant that these institutional structures were destabilised (Abeysinghe et al, 2017). The combination of these factors allowed for conditions where medical expertise could be redefined: the perceived failures of the government in risk communication left a pressing community need, and the reconstruction of health-care structures allowed for conditions under which institutional change was possible (Hall, 2010).

As a result, medical professionals began to undertake work in defining, measuring, and communicating the health risks posed by radiation exposure for the local community. As part of this, the expertise of these medical doctors and paraprofessionals was reconstituted and stretched in various ways – both in terms of social-sanctioned fields of expert knowledge and in the particular practices under which this knowledge was exercised within action. New positions of expertise were taken up and evident through the community trust in the ability of the professions to measure and communicate radiation risk. In terms of changing practices this included: new or changing tasks for individual doctors (for example, moving specialty or creating expertise around radiation); new roles in creating means for measuring (for example, BabyScan) or understanding (for example, radiation maps) the risk of radiation and thereby reducing community uncertainty; changing and more engaged roles in the community (for example, undertaking tasks aimed at alleviating social isolation and promoting use of the hospital to deal with health issues); and roles in translating this information for community leaders (for example, in communicating risk to key stakeholders such as school official or City Office workers and policy makers). Some activities are clearly particular to the post-disaster context, while others (such as community engagement and advocacy around health services) provide a useful empirical example through which to envisage the implementation of discursive calls and commentaries around further professional engagement and advocacy (Medical Professionalism Project, 2002; Croft et al, 2012)

These new roles can be understood as a shift between normal expertise and post-normal forms of expertise, in a form that reflects the specific nature of medical professional practice (as opposed to scientific practice). It is clear that these professionals have stepped outwith the bounds of socialised medical expertise and specialisms, and that they act as trusted experts in the new realm of radiation and post-disaster risk. Further, as evident within mode-2 forms of expertise (Nowotny, 2003), the questions that underpin these endeavours are drawn from the community. This suggests that the literature on medical expertise can look to wider discussions of expertise (drawn from the analysis of mode-2 science) in understanding the nature of medical engagements with public concerns. This particular case study also adds to aspects of the mode-2 literature. Since that literature emphasises environmental policy and its interface with science, many examples of mode-2 expertise focus upon the way in which scientists have become quasi-policy actors (Nowotny et al, 2001) or served to answer questions asked by policy or public actors (Nowotny, 2003). However, in contrast to that literature, the particular stretching of expertise for Fukushima medical professionals cohered with the specific functions of the medical profession. While interactions with policy makers and the media were evident, other forms of stretching expertise (for example, in becoming trusted experts on radiation) have a distinct and more microsociological/interactive quality in comparison to most studies of mode-2 science (which tend to focus on the level of national or global policy).

The case study also suggests some consequences that have not been clearly articulated in the literature on mode-2 expertise, especially where this work might be fruitfully integrated with health sociological literature on medical dominance. First, the contrast between the narratives produced by medical professionals/paraprofessionals engaged in expanded forms of expert work and other professional groups who have experienced deprofessionalisation suggests that institutional ramifications of shifting medical expertise need to be examined further. Is, as the established literature on professional dominance suggests (Willis, 1990; Coburn and Willis, 2000), the expansion of expertise necessarily or generally related to the constriction of other professional categories? If so, what do calls for greater professional community and policy engagement potentially mean for the deprofessionalisation of other medical workers? While this particular case study does shed some light on these issues, further work on this question (in relation to both the medical profession and other forms of mode-2 expertise) would be useful in interrogating whether these patterns have a different quality to traditional professional dominance and boundary making.

It is also evident from this study that the expansion of expertise is embodied in particular doctors and senior paraprofessionals, rather than all workers of a similar category. The particular tasks undertaken also mirror the personal interests of individuals. This might suggest that the move into mode-2 expertise is not a reconfiguration of an entire professional category, but rather of specifically motivated and placed individuals (as opposed to paradigmatic moves into mode-2 science).

Lastly, it is also worth further interrogating the link between these post-normal forms of expertise and the issue of democratised science. This literature tends (see Ravetz, 2004) to associate post-normal expertise with democratisation, given that a fundamental characteristic of post-normal expertise is the focus on risks of policy and societal importance. While this linking between post-normal medical experts and community problems clearly did occur, the forms of evidence that were produced still tended to be framed through biomedical models of public communication and

education. After the 3.11 disaster, citizen science groups around radiation measurement have grown (see Brown et al, 2016; Kimura and Kinchy, 2016), and they produce lay accounts of radiation that sometimes contradict both government and medical expert accounts. Within the present case study, the goal of these new measurement and communication activities is to communicate risk measurements to (and for) the public, rather than to co-produce understandings of risk with the public. In this particular case, it should be noted that the knowledge produced by these medical experts is sometimes contested by individual patients/citizens, as had been noted in some interviews. This form of radiation risk measurement can therefore be seen as an activity divorced from the state (in that it is not based upon state-produced measures) but also divorced from citizen-produced measures. The relationship and tensions between these evidences and expertises – government, medical, and citizen – would be a fruitful area of further research, particularly in understanding how new medical evidence around radiation translates both lay and official accounts.

Conclusion

Drawing upon interview data with medical professionals in Minamisoma, Fukushima, this paper has demonstrated the rise of a new form of medical evidence gathering and expertise. The public's lack of faith in the government handling and accounts of the Fukushima disaster resulted in distrust of official communications around radiation exposure and the attendant health implications. Under these conditions, medical professions were well-placed to collect and communicate the problem of radiation risk. Doctors and senior paraprofessionals engaged in the collection of new evidence around radiation exposure, the classification and representation of this exposure, and the communication of the information to local people. In doing so, these individuals stepped out of their classical professional training and inhabited new roles as post-normal experts.

This resulted in a changed relationship between medical sites and the community, and a changed experience of medical work for these experts. This shift impacted both individual workers and health-care institutions. Staff travel into the community to undertake engagement and to mediate interventions for social issues presented by the post-disaster setting (such as higher rates of isolation). The new post-normal medical experts enjoy an expansion of their domain of expertise, and more varied and enriching work tasks. At the same time, other categories of worker (such as lower-status medical paraprofessionals) have experienced a narrowing of expertise and professional practice in the post-disaster period.

The study indicates that the work of the medical professions can be understood through the concept of post-normal expertise, and suggests that calls for further medical professional engagement with policy and public questions might be interrogated through the lens of this literature. At this same time, some of the consequences of this shift need further investigation. These include the impact on other professional categories, interrogating the relationship between this new medical knowledge and citizen and government accounts, and investigating whether this is a change in whole professional categories or only for selected individuals.

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Conflict of interest
The authors declare that there is no conflict of interest.

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