

## Infection surveillance after a natural disaster: lessons learnt from the Great East Japan Earthquake of 2011

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**Problem** On 11 March 2011, the Great East Japan Earthquake produced a catastrophic tsunami that devastated the city of Rikuzen-Takata and left it without an effective health infrastructure and at increased risk of outbreaks of disease.

**Approach** On 2 May 2011, a disease-surveillance team was formed of volunteers who were clinicians or members of Rikuzen-Takata's municipal government. The team's main goal was to detect the early signs of disease outbreaks.

**Local setting** Seven weeks after the tsunami, 16 support teams were providing primary health care in Rikuzen-Takata but the chain of command between them was poor and 70% of the city's surviving citizens remained in evacuation centres. The communication tools that were available were generally inadequate.

**Relevant changes** The surveillance team collected data from the city's clinics by using a simple reporting form that could be completed without adding greatly to the workloads of clinicians. The summary findings were reported daily to clinics. The team also collaborated with public health nurses in rebuilding communication networks. Public health nurses alerted evacuation centres to epidemics of communicable disease.

**Lessons learnt** Modern health-care systems are highly vulnerable to the loss of advanced technological tools. The initiation – or re-establishment – of disease surveillance following a natural disaster can therefore prove challenging even in a developed country. Surveillance should be promptly initiated after a disaster by (i) developing a surveillance system that is tailored to the local setting, (ii) establishing a support team network, and (iii) integrating the resources that remain – or soon become – locally available.

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### Introduction

On 11 March 2011, north-eastern Japan experienced one of the most catastrophic natural disasters ever recorded – the huge tsunami that resulted from the Great East Japan Earthquake.<sup>1</sup> In Rikuzen-Takata, in Iwate prefecture, a 16 m-high wave swept across 85% of the city and damaged or destroyed many buildings, including the four-storey city hall, the prefectural hospital, seven of the city's nine health clinics and all nine of its pharmacies (Appendix A, available at: <https://dl.dropboxusercontent.com/u/27176676/online/BLT13117945/Appendix.pdf>). Overall, 1730 citizens – or 7.4% of the city's population, including two physicians, six public health nurses and many other health-care professionals – were killed or presumed to have been killed by the tsunami.<sup>2</sup> The city's health-care system – which had had a shortage of physicians even before the disaster – was left in total disarray. The Iwate prefectural government soon called in health-care support teams from elsewhere in Japan.

By early May 2011 – 7 weeks after the disaster – 16 teams of local or visiting clinicians and one team of public health nurses were providing health care in Rikuzen-Takata.<sup>3</sup> At the same time, 15 804 refugees – 70% of the city's surviving citizens – were still living in the 88 village halls, factories, schools and indoor sports facilities that had been converted

into evacuation centres (Appendix A).<sup>4</sup> Most of these evacuation centres were overcrowded and had inadequate insulation and air conditioning. The city had a working mobile phone network at this stage but the signal was weak in coastal and rural areas. The city's electricity, water and sewerage services remained disrupted in most areas.<sup>5</sup>

After the tsunami, infection surveillance was urgently required to protect Rikuzen-Takata's refugees from major outbreaks of communicable disease.<sup>6</sup> However, it soon became clear that the chain of command among local government administrators and the city's health-care support teams was too weak to permit effective surveillance.<sup>2</sup> Approximately 1 month after the disaster, the Iwate prefectural government therefore formed a taskforce to facilitate infection surveillance (Appendix A).<sup>7,8</sup> Between 13 April and 16 August 2011, this taskforce used a specialized tablet computer to collect information on cases of infection from the evacuation centres – about 300 – that then existed in Iwate prefecture. The taskforce, which collected data from a mean of 13.2 centres per day, included a mobile support team. The taskforce's surveillance data allowed the mobile team to alert refugees to potential disease outbreaks.<sup>8</sup> However, the data were not made available to most of the other health-care support teams working in the city or even to the city's Health Service Bureau. On 23 April 2011, nine clinics that had been established – or re-established – after

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the disaster initiated their own surveillance for influenza, measles, enteritis and scabies in Rikuzen-Takata. This was a response to a recommendation of a health-care team from Kobe – a city that was left devastated by an earthquake in 1995. Although the clinic data were assimilated at daily coordination meetings, they were never systematically analysed.

The main aims of our project were to establish an efficient system of infection surveillance to cover all of the clinics in Rikuzen-Takata – using only the resources that were locally available – and to maintain this system until most of the evacuation centres had been closed.

## Strategy and process

A surveillance-specific “working team” of seven volunteers – who had then already been collaborating for about 1 month – was formed on 2 May 2011 (Appendix A). This team comprised a government officer from Rikuzen-Takata’s Health Service Bureau and physicians and paediatricians from Iwate Prefectural Takata Hospital in Rikuzen-Takata or St Mary’s Hospital in Kurume. The members of the team contributed to the project on a part-time basis and had other daily tasks.

Immediately after its creation, the working team spent three days interviewing representatives of the 16 health-care support teams that were then operating in Rikuzen-Takata. Their aim was to assess local conditions and determine the resources that were locally available. Eight of the support teams were based in the Takata or Yonesaki districts of Rikuzen-Takata (Appendix A) and six of the other teams joined twice-daily coordination meetings at Yonesaki. However, most of the support teams provided their services on a stand-alone basis and the chain of command among the teams was poor. All of the support teams encouraged the launch of a unified system of infection surveillance in Rikuzen-Takata. A reporting format for cases of infectious disease that was consistent with pre-existing surveys, minimally burdensome and flexible – in terms of the methods that could be used to pass on the data for assimilation and analysis – was commonly requested. The working team concluded that (i) infection surveillance should be clinic-based, to detect early outbreaks; (ii) the adverse impact of infection surveillance on clini-

cians’ workloads should be minimized by introducing a simple reporting format, and (iii) the main problems in communication – for example, for the daily submission of completed report forms to the working team and for alerting the relevant health-care professionals about any increased risk of a disease – could probably be overcome by establishing a communication network at the “grass-roots” level.

### Draft and refinement of protocol

The two infection surveillance systems that had already been explored in Rikuzen-Takata after the tsunami were both based on a reporting format recommended by the United States Centers for Disease Control and Prevention.<sup>9</sup> The working team drafted a simple reporting format that combined aspects of these earlier systems. To promote the new surveillance project, the working team visited each clinic in Rikuzen-Takata in the company of the existing team of public health nurses – who had all volunteered to support the project. During these visits, time trend data from earlier, preliminary surveillance were presented. Participants – the clinicians working for the support groups in the clinics – were told that they could use any available communication method to report cases of infection – to the Health Service Bureau, a support group coordination meeting or a public health nurse – or to obtain feedback data from the working team. For example, they could use mobile or landline telephones, facsimile machines or the internet, or simply hand a completed paper surveillance form to a public health nurse. The working team closely shared information and strategies with Rikuzen-Takata’s municipal government. The protocol for the project was also reported to the Iwate Public Health Unit to confirm its consistency with the prefectural government’s strategy for disease surveillance.

### Launch and operation of surveillance project

A surveillance form was released as a pilot version on 4 May 2011, and as a final version 2 days later (Appendix A) – when the protocol for the project was approved by all 16 support teams in Rikuzen-Takata and comprehensive data collection commenced. Data recorded on the forms by clinicians working in the support teams were collected daily by the Health Service Bureau from four

support teams in Takata. Another 10 support teams submitted completed surveillance forms at daily coordination meetings in Yonesaki or via public health nurses. Two other support teams submitted data from the forms daily, using a facsimile machine or a landline telephone.

One member of the working team – using Excel 2007 (Microsoft, Redmond, United States of America) and a tailor-made macro – developed a database format to facilitate the semi-automated analysis of the surveillance data and the preparation of summary findings. Each day, time trend data on the incidence of each recorded infectious disease over the previous two weeks were sent to each support team (Appendix A). These summary results were also displayed at each major base used by any of the support teams. As they visited the support teams, the public health nurses regularly thanked the participants and encouraged further data collection. At the start of the project, the members of the working team each spent up to 50% of their daily work time on the project protocol and its implementation. However, once the project had been running for a few weeks, the daily time that the working team spent on the project fell substantially, partly thanks to the concurrent restoration of landline telephone lines throughout most of Rikuzen-Takata. Subsequently – despite the gradual decline in the visiting workforce – infection surveillance was maintained, at an average response rate of 96.2%, until the end of the project. The project was terminated on 13 July 2011, when most of the evacuation centres had been closed and Iwate Prefectural Takata Hospital had been re-opened, albeit at a temporary site (Appendix A). The quality of the surveillance data that formed the focus of the project was deemed to be generally satisfactory. Records that were incomplete or ambiguous were rarely encountered. The quantity of additional, voluntary information that was assimilated – such as descriptions of specific cases of some diseases – varied significantly according to the support team involved.

Support teams were alerted – by the working team – whenever the working team thought it had detected the early signs of an outbreak of a communicable disease, such as the observation of at least two cases of antigen-positive influenza on each of the previous two days.

If the suspected outbreak continued to expand, refugees and other citizens were also alerted, either by the Health Service Bureau – generally via an announcement in the weekly bulletin that was published, in printed format, by Rikuzen-Takata's municipal government – or by the team of public health nurses. The public health nurses advised the staff working in evacuation centres on how best to isolate patients with highly contagious diseases – such as influenza and norovirus enteritis – within the limited space that was available. For the other communicable diseases that were observed – such as common cold, mumps and hand, foot and mouth disease – the cases, their caregivers and neighbouring refugees were offered preventative measures such as facemasks and alcohol-based hand washes.

### Findings from the infection surveillance

During the project, 16 587 patients were seen by clinicians working for the support teams in Rikuzen-Takata. Of these patients, 44.3% were older than 64 years and only 9.6% were younger than 15 years (Appendix A). The most frequently reported problem was respiratory disease (1437 cases), followed by gastrointestinal illness (301), skin or soft-tissue lesions (164) and fever (20). Neuromuscular disorders (7) and jaundice (1) were also formally recorded, whereas cases of some other diseases, such as mumps, were only mentioned in the “comments” section of report forms. The incidences of respiratory illness and gastrointestinal illness were both highest at the commencement of the surveillance. Influenza viral infection was confirmed – with a positive antigen test – in each of 113 patients. Small outbreaks of mumps and of hand, foot and mouth disease were mentioned on the report forms, in May 2011 and June 2011, respectively. None of the recorded disease outbreaks developed into a serious epidemic or pandemic.

### Discussion

Health-care systems in developed countries are heavily dependent on modern technology and are, in consequence, very vulnerable to natural disasters such as the Great East Japan Earthquake. The tsunami that struck Rikuzen-Takata in 2011 left no effective system of disease surveillance. It also hampered early

attempts to re-establish such a system because it broke the necessary chains of command and devastated the city's communication network. The failures of these early attempts were, however, soon recognized and – as the city's whole infrastructure was slowly rebuilt – a new and effective system of disease surveillance was created from the resources that were locally available. In the post-disaster development of a health-care system, the formation of at least one on-site “working team” that can optimize the system for the local setting and facilitate a support team network using the best available resources should be considered.

### Post-disaster infection surveillance today

To protect the survivors of natural disasters from diseases,<sup>10,11</sup> the prompt establishment – or re-establishment – of a system of infection surveillance is essential.<sup>12,13</sup> Infection surveillance is known to have played an important role in preventing outbreaks of communicable diseases following the 2004 Indian Ocean earthquake and the 2008 Sichuan earthquake.<sup>13,14</sup> After the Great East Japan Earthquake, primary medical care was rapidly provided by the development of several stand-alone clinics that were run by local and visiting teams of health personnel. The rigorous cooperation between support teams and the effective communication network – that, together, would allow the rapid redevelopment of an effective city-wide system of health care – took longer to develop.

### Initiation of infection surveillance

To overcome the lack of an efficient command chain among the health-care support teams that worked in Rikuzen-Takata in the months immediately after the 2011 tsunami, the Iwate prefectural government created a small taskforce and provided it with a tablet computer to facilitate infection surveillance in the evacuation centres.<sup>7,15</sup> This taskforce was able to take advantage of the early creation of a mobile phone network that covered all of the larger evacuation centres. While precious information was collected by the taskforce, the benefit of that information to the health-care support teams working in Rikuzen-Takata at the time was very limited. The taskforce covered too small a population and used an inflexible and relatively ineffective system for disseminating the

data to those who would have found them useful.<sup>8</sup>

In an attempt to overcome the taskforce's limitations, we aimed to establish clinic-based surveillance across the whole of Rikuzen-Takata. As many modern methods of communication remained unavailable at the smaller evacuation centres and clinics, we allowed and encouraged participants to use whatever methods were available to them. Most participants simply passed their completed surveillance forms to a member of the working team or a public health nurse and none used e-mails to submit their data. The clinic-based surveillance system benefited from reliable information provided by medical professionals. The difference between the incidence of antigen-test-positive influenza recorded in the clinic-based surveillance (0.07 cases per 1000 citizens per day) and the incidence of influenza-like illness recorded in the evacuation-centre-based surveillance (0.6 cases per 1000 evacuees per day)<sup>8</sup> illustrates the degree to which the results obtained with the two approaches can differ.

### Resources needed for infection surveillance

Careful assessment of local settings and the development of a support team network are essential for the optimal implementation of post-disaster health-care strategies and, for this, the creation of an active on-site “working team” is recommended. As our working team was not supported by specific funding, its members had to divert a substantial amount of their work time to the project, although they were all formally employed to conduct other activities. However, after the clinic-based system of infection surveillance had been implemented for a week, the members of the working team had to spend much less time on the system. This trend was the combined result of a smooth-running system once any “teething” problems had been resolved and the once-novel procedures had become routine, the semi-automated nature of the system of data-processing, and the concurrent restoration of the landline telephone system in Rikuzen-Takata.

### Post-tsunami infectious disease outbreaks

Following tsunamis, an atypical form of pneumonia known as “tsunami lung” has been reported in survivors who nearly

drowned.<sup>16,17</sup> We observed an outbreak of respiratory illness in May 2011 but the symptoms were generally confined to a cough.<sup>18</sup> Given that this outbreak did not appear to affect children younger than 5 years – who generally spent more time indoors after the disaster than their adult counterparts – the symptoms might be attributed to dusty tsunami debris in the air.<sup>19</sup> Outbreaks of gastrointestinal illness and influenza were also noted. Precautionary measures and isolation of patients might prevent further cases of these diseases.

## Conclusion

Our observations in Rikuzen-Takata indicate that efficient infection surveillance can be swiftly established after a catastrophic natural disaster, even without specific funding or the full-time employment of dedicated staff. Health-care support teams should be allowed to use the best method of communication that remains available. Ideally, an on-site multidisciplinary working team – which can assess region-specific characteristics of the disaster area and establish rigor-

### Box 1. Summary of main lessons learnt

- Modern health-care systems are highly vulnerable to the loss of advanced technological tools.
- The support teams responsible for re-establishing primary health care following a catastrophic disaster need to cooperate and form an effective but flexible network of communication, data collection and data feedback that is carefully adapted to the local setting.
- The resources that remain – or become – locally available need to be integrated into the surveillance system and to be fully exploited.

ous cooperation between the various support teams using the best available resources (Box 1) – should be formed. ■

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## ملخص

### ترصد العدوى بعد كارثة طبيعية: الدروس المستفادة من زلزال شرق اليابان الكبير في عام 2011

عيادات المدينة باستخدام استمارة تبليغ بسيطة يمكن إجراؤها دون إضافة حمل كبير على الأعباء العملية للأخصائيين السريريين. وتم إبلاغ العيادات بملخص النتائج يوميا. كما تعاون الفريق مع مرضي ومرضات الصحة العامة في إعادة بناء شبكات التواصل. وقام ممرضو الصحة العامة بتنبيه مراكز الإجلاء حول الأوبئة الأمراض المعدية.

الدروس المستفادة أنظمة الرعاية الصحية الحديثة معرضة بدرجة عالية لفقدان الأدوات التكنولوجية المتقدمة. ولذلك فإن بدء - أو إعادة تأسيس - ترصد الأمراض بعد الكوارث الطبيعية يمثل تحديا حتى لو كان ذلك في بلد متقدم. وينبغي بدء الترصد سريعا بعد الكارثة من خلال (1) وضع نظام ترصد مفصل حسب البيئة المحلية، (2) تأسيس شبكة من فرق الدعم، (3) إدماج الموارد التي تظل - أو تصبح عن قريب - متوفرة محليا.

المشكلة في 11 مارس/ آذار 2011، تسبب زلزال شرق اليابان الكبير في حدوث موجة تسونامي كارثية دمرت مدينة ريكوزين - تاكاتا وتركتها بدون بنية أساسية صحية فعالة وعرضة لخطر متزايد من تفشي الأمراض.

الأسلوب في 2 مايو/ أيار 2011، تم تكوين فريق لترصد الأمراض من المتطوعين الذين كانوا من الاختصاصيين السريريين أو أعضاء الحكومة البلدية لمدينة ريكوزين - تاكاتا. وكان الهدف الرئيسي للفريق اكتشاف العلامات المبكرة لتفشي الأمراض.

المواقع المحلية بعد سبعة أسابيع من التسونامي، كان هناك ستة عشر فريقا من فرق الدعم تقدم الرعاية الصحية الأولية في ريكوزين - تاكاتا، ولكن تسلسل القيادة بينها كان ضعيفا وظل 70٪ من المواطنين الناجين في المدينة في مراكز الإجلاء. وبشكل عام كانت أدوات الاتصال المتوفرة غير كافية.

التغيرات ذات الصلة قام فريق الترصد بتجميع البيانات من

## 摘要

### 自然灾害后的感染监控：从 2011 年东日本大地震吸取的教训

**问题** 2011 年 3 月 11 日，东日本大地震引发灾难性的海啸，摧毁了官城 - 高田市，使其缺乏有效的卫生基础设施，增加了疾病爆发的风险。

**方法** 2011 年 5 月 2 日，临床医生或官城 - 高田市政府成员志愿者组成了疾病监测小组。小组的主要目标是

发现疾病爆发的早期迹象。

**当地状况** 在海啸发生七周后，16 个支援队伍在官城 - 高田提供基本医疗护理，但是队伍之间的指挥链条不完善，城市 70% 的幸存市民仍留在避难中心。可用的沟通工具普遍比较缺乏。

**相关变化** 监测小组使用一种简单的报告表从城市诊所收集数据，临床医生不用另外花费很多精力就可填写好这个表格。每日向诊所报告汇总结果。小组还与公共卫生护理人员合作重建沟通网络。公共卫生护理人员向避难中心发出传染病爆发的警告。

**经验教训** 现代护理系统非常害怕失去先进的技术工

具。因此，即使在发达国家，在自然灾害后启动（或重建）疾病监测也充满挑战。应在自然灾害后立即启动监测，借助的手段有 (i) 发展根据当地条件因地制宜的监测系统，(ii) 建立支援队伍网络，(iii) 整合在当地保留下来（或很快能够得到）的资源。

## Résumé

### Surveillance de l'infection après une catastrophe naturelle: leçons tirées du grand tremblement de terre dans l'est du Japon en 2011.

**Problème** Le 11 mars 2011, le tsunami catastrophique provoqué par le grand séisme dans l'est du Japon dévastait la ville de Rikuzen-Takata en la laissant sans infrastructure de santé efficaces et avec un risque accru de flambées d'épidémies.

**Approche** Le 2 mai 2011 s'est constituée une équipe de surveillance des maladies, formée de volontaires cliniciens ou membres du gouvernement municipal de Rikuzen-Takata. L'objectif principal de l'équipe était la détection des signes précoces d'épidémies

**Environnement local** Sept semaines après le tsunami, 16 équipes de soutien fournissaient des soins de santé primaires à Rikuzen-Takata mais la hiérarchie entre elles restait faible et 70% des citoyens survivants se trouvaient encore dans des centres d'évacuation. Les outils de communication disponibles étaient généralement inappropriés.

**Changements significatifs** L'équipe de surveillance a collecté des données dans les cliniques de la ville en utilisant un simple formulaire

de rapport pouvant être complété sans trop ajouter au travail des cliniciens. Les résultats étaient communiqués quotidiennement aux cliniques. L'équipe a également collaboré avec des infirmiers de la santé publique pour rétablir les réseaux de communication. Les infirmiers de la santé publique alertaient les centres d'évacuation des épidémies de maladies transmissibles.

**Leçons tirées** Les systèmes de santé modernes sont fortement vulnérables à la perte des outils technologiques de pointe. L'initiation – ou le rétablissement – de la surveillance des maladies à la suite d'une catastrophe naturelle peut donc se révéler difficile même dans un pays développé. La surveillance devrait pouvoir être initiée rapidement après la catastrophe en (i) développant un système de surveillance à la mesure des installations locales, en (ii) établissant un réseau d'équipes de soutien et en (iii) intégrant les ressources qui demeurent – ou peuvent rapidement être – disponibles localement.

## Резюме

### Эпиднадзор в районах, пострадавших от стихийных бедствий: уроки Большого восточно-японского землетрясения 2011 г.

**Проблема** 11 марта 2011 г. катастрофическое цунами, вызванное Большим восточно-японским землетрясением, обрушилось на город Рикузентаката, фактически уничтожив в нем всю инфраструктуру здравоохранения и резко повысив риск возникновения эпидемиологической ситуации.

**Подход** 2 мая 2011 г. была сформирована добровольческая эпиднадзорная бригада, в состав которой вошли медики и члены рикузентакатского муниципалитета. Основной задачей бригады было выявление первых признаков вспышек заболеваний.

**Местные условия** Через семь недель после цунами в Рикузентакате функционировали 16 бригад первичной медико-санитарной помощи, однако их взаимодействие оставляло желать лучшего, и 70% выживших жителей города оставались на эвакуационных пунктах. Имеющиеся средства связи по большей части были неадекватными.

**Осуществленные перемены** Эпиднадзорная бригада вела сбор данных из городских клиник методом простого анкетирования,

не слишком обременительного для медицинских специалистов. Результаты анкетирования ежедневно обобщались и передавались в клиники. Бригада также помогала санитарам системы общественного здравоохранения в восстановлении коммуникационных сетей. Санитары оповещали персонал эвакуационных пунктов об эпидемиях заразных болезней.

**Выводы** Современные системы здравоохранения чрезвычайно уязвимы к утрате сложных технических средств, и развертывание или восстановление системы эпиднадзора после стихийных бедствий оказывается довольно проблематичным даже в развитых странах. В пострадавших районах эпиднадзор необходимо начинать немедленно посредством (i) развертывания адаптированной к местным условиям системы надзора, (ii) организации взаимодействия между бригадами обеспечения и (iii) задействования уцелевших или восстанавливаемых местных ресурсов.

## Resumen

### Control de infecciones después de un desastre natural: lecciones aprendidas del Gran Terremoto del Este de Japón de 2011

**Situación** El 11 de marzo de 2011, el Gran Terremoto del Este de Japón ocasionó un tsunami catastrófico que devastó la ciudad de Rikuzen-Takata y la dejó sin una infraestructura sanitaria eficaz y con un riesgo mayor de sufrir brotes de enfermedades.

**Enfoque** El 2 de mayo de 2011, se formó un equipo de control de enfermedades constituido por voluntarios médicos o miembros del gobierno municipal de Rikuzen-Takata. El objetivo principal del equipo era detectar los primeros signos de brotes de enfermedades.

**Marco regional** Siete semanas tras el tsunami, había 16 equipos de asistencia encargados de proporcionar atención primaria sanitaria en Rikuzen-Takata, pero con una cadena de mando débil entre ellos, por lo que el 70% de los ciudadanos que sobrevivieron permanecieron en centros de evacuación. Las herramientas de comunicación disponibles fueron, en general, insuficientes.

**Cambios importantes** El equipo de control recibió los datos de las clínicas de la ciudad a través de un formulario de informe sencillo que se

podía completar sin que la carga de trabajo de los médicos aumentara demasiado. Se informaba diariamente a las clínicas sobre el resumen de los resultados. Asimismo, el equipo colaboró con los enfermeros de salud pública en la reconstrucción de las redes de comunicación. Los enfermeros de salud pública alertaron a los centros de evacuación acerca de las epidemias de enfermedades transmisibles.

**Lecciones aprendidas** Los sistemas de salud modernos son muy vulnerables a la pérdida de herramientas tecnológicas avanzadas. Por

tanto, la iniciación (o el restablecimiento) del control de enfermedades tras un desastre natural puede resultar un reto, incluso en países desarrollados. El control debe iniciarse inmediatamente tras un desastre mediante (i) el desarrollo de un sistema de control adaptado al contexto local, (ii) el establecimiento de una red de equipo de asistencia, y (iii) la integración de los recursos restantes o que vayan a estar disponibles pronto a nivel local.

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