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Shakti Shrestha, Caroline Orchiston, Kenneth Elwood, David Johnston, Julia Becker, Isabella Tomassi

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Understanding the wider social and economic context of Post-Earthquake Cordons: A comparative case study between Christchurch, Aotearoa (New Zealand) and L'Aquila, Italy

Shakti R. Shrestha; Caroline H.R. Orchiston; Kenneth J. Elwood; David M. Johnston; Julia S. Becker and Isabella Tomassi

Abstract

Post-earthquake cordons have been used after seismic events around the world. However, there is limited understanding of cordons and how contextual information such as geography, socio-cultural characteristics, economy, institutional and governance structures affect decisions and operational procedures, including aspects related to spatial and temporal attributes of cordon establishment. This research aims to fill the gap in cordon knowledge through a qualitative comparative case study of two cities: Christchurch, New Zealand (M_w 6.2 earthquake, February 2011) and L'Aquila, Italy (M_w 6.3 earthquake, 2009). Both cities suffered comprehensive damage to their city centres and had cordons established for extended periods of time. Data collection was done through purposive and snowball sampling whereby 23 key informants were interviewed in total. Research participants held expert knowledge in their roles and responsibilities i.e., council members, emergency managers, politicians, business/insurance representatives, academics, and police. Results illustrate that, cordons were primarily established to ensure safety of people and to maintain security. The extent and duration of the cordons were affected by the recovery approaches taken in respective cities i.e., in Christchurch demolition was widely undertaken which supported recovery and allowed for faster removal of cordons. In contrast, authorities in L'Aquila placed high value on heritage buildings which led to recovery strategy based on preserving and restoring most of the buildings which extended the duration of cordon. Extended cordons have many similarities but evolve overtime. This evolution of cordons is affected by site specific needs, thus, cordons should be understood and planned based on contextual realities.

Key words

Earthquake, cordons, emergency management, disaster response, , recovery, life safety

1. Introduction

Earthquakes, among other natural hazards, pose the highest risk to life safety. Disasters due to seismic events have accounted for 56% of total deaths between 1998-2017 worldwide [1]. This risk is primarily due to building collapse and falling debris. However, secondary earthquake hazards such as tsunamis, fire hazards and landslides also pose considerable risk to life safety. Even the cascading effects due to secondary hazards can be devastating as evident by the 2011 Fukushima Daiichi nuclear disaster [2]. The risk due to earthquakes is extended beyond the initial shaking as major seismic events are followed by aftershocks of varying magnitude that last for months or years after the mainshock. The aftershocks are usually smaller than the initial main event (the largest is typically one magnitude less than the mainshock) [3] and the frequency also number decreases over time [4]. However, frequent aftershocks could significantly compromise the structural integrity of undamaged structures and further damage or weaken buildings, potentially leading to falling debris and/or collapse. As a disaster management tool, cordons have been used for extended periods in response to the challenges of managing risk in the aftermath of major seismic events [5], to exclude the public from high-risk areas to protect their safety, as well as to

expedite building assessments, demolitions, and restoring services. This is because cordons discourage people from entering dangerous areas thereby protecting them from getting hurt.

1.1. Earthquakes and context

Earthquakes cause ground motions that can damage the built and social environments, cause psychosocial trauma for inhabitants and lead to uncertainty for communities and decision-makers. The intrinsic attributes of earthquakes, such as magnitude, frequency, focal depth, epicentre location, time of day and time of year are factors that influence risks [6]. These attributes however are only a piece of the puzzle that determines actual risks to life safety. Understanding the local context of the affected area can inform the level of risk posed by seismic events and guide appropriate response strategies. Similarly, recovery and reconstruction policies need to be contextually sound to be effective [7,8].

Population density, building density, structural integrity of built structures, urban planning choices, risk awareness and preparedness and socio-economic parameters are additional factors that influence vulnerability of a given location and its residents. The influence of these additional elements has been highlighted in recent major seismic events. For example, the magnitude 7.0 Haiti earthquake of 2010 caused an estimated 230,000 deaths and similar numbers of injured people [9] while more than 50% of the housing in the capital city sustained extensive damages [10]. In stark contrast, there were no deaths due to the magnitude 7.1 Darfield earthquake (2010) in New Zealand even though it affected 300,000 people. This contrast is partly attributed to New Zealand's strict building code [1]. It should be noted that the Darfield earthquake occurred at 4:35 AM and the epicentre of the earthquake was in a rural, sparsely populated location [11]. This meant that most residents were still in bed at the time of impact limiting their exposure to risk from falling masonry in the denser city centre.

The case of Haiti also points towards the failure of policies and political ideologies that, in parts, created the vulnerabilities long before the actual seismic event occurred [9,12]. Massive population growth in the two decades prior to the earthquake [12] and subsequent housing demands of citizens with limited economic capacity resulted in prolific construction of cheap, poorly constructed housing. A tragic consequence followed as 86% of the houses built since 1991 were completely destroyed [13], and significantly contributed to the number of deaths after the quake. A comparison with New Zealand, however, presents a divergent story of earthquake impacts, especially in terms of mortality rates. New Zealand has had a number of strong earthquakes in the last century, the 2011 Christchurch earthquake being the most devastating since 1931. The economic cost of the 2011 earthquake resulted in NZ\$40 billion dollars in financial loss [14] but the mortality rate was relatively low at 185 deaths (albeit one of the highest in the history of New Zealand). This was not a coincidence but a result of sustained effort over a century at the institutional level to improve the resilience of buildings through advancements in research and implementation through the building codes [15,16].

Japan, which is one of the most earthquake prone countries in the world has developed a range of earthquake risk mitigation and preparedness strategies from national to local level (see [17,18]). This has led to lower mortality rates for similar magnitude earthquakes compared to developing nations. Additionally, higher economic capacity along with improvement in building codes to address seismic risks after the 1995 Kobe earthquake meant that the magnitude 6.2 Tokyo earthquake in 2009 resulted in just one death even though it affected 2.75 million people [19]. USA is another developed nation which has not suffered high numbers of fatalities due to earthquakes in the last few decades [20]. The differences due to economic capacity are not limited to mortality

rates as people from low-income countries, on average, are six times more likely to be displaced/evacuated, injured, lose their homes or require emergency services than citizens of developed countries [1]. The obvious difference in outcomes due to earthquakes warrants that preparedness, response and recovery planning consider contextual information to be feasible and effective. To this end, use of cordons are no exception.

A cordon is a visible barrier used by an authorized institution to temporarily manage access to and from a given site during critical situations. In relation to earthquakes, the criticality of the situation is indicated by the risks from damaged buildings and potential falling debris due to aftershocks that follow major seismic events [21]. Cordons impose a strict spatial demarcation that delineates the degree of safety and security within it. Often, cordons are used for areas encompassing more than one building which was observed in both Christchurch and L'Aquila. The cordons referred to in this paper are from contexts that utilized large cordons as a life safety measure during the response. A cordon established following a seismic event to control the movement of people into affected areas can be termed as post-earthquake cordons (PEC). Although PECs have been used around the world in various ways through time and space, their use (especially for extended periods i.e., more than a month) is an exception and not the rule. Even when established, PECs are poorly documented, and sometimes not documented at all [22] which hints at the lack of understanding of cordons and their potential significance as a disaster management tool. However, there is rising interest in PECs and their implications on response and long-term recovery [23–26]. This paper aims to add to the growing body of literature of PECs by comparing two case study sites: Christchurch, New Zealand and L'Aquila, Italy where cordons were established and maintained for more than two years after respective seismic events. In Italy, cordons and the space encompassed by the cordon is called *zona rossa* or red zone, and this term was also used in Christchurch. The case studies are described in detail in the next section.

2. Methodology

For the purpose of this research, two case study sites were selected: Christchurch in Aotearoa-New Zealand (NZ) following the 2011 earthquake and L'Aquila, Italy, after the 2009 earthquake. Both cities suffered extensive damage after their respective earthquakes and share a common post-earthquake response in the use of cordons. They also share similarities in the use of PECs over large spatial and temporal scales which has not been observed in other parts of the world after a major seismic event. Although the damages in both cities were widespread geographically, this study focuses primarily on the city center of each city where the primary cordons were in place.

2.1. Christchurch, New Zealand

On February 22nd, 2011, a major 6.2 M_w earthquake struck the city of Christchurch. This earthquake was an aftershock which followed the 4 September 2010 7.1 M_w Darfield earthquake. Although smaller in magnitude, the Christchurch earthquake was shallow (depth 5km) and much closer to the central business district (CBD). This caused significant destruction resulting in the loss of 185 lives and total or partial collapse of thousands of buildings. More than one third of the buildings within the CBD were completely destroyed [27]. As a consequence, emergency managers established a cordon around the CBD. Due to the scale of damage, a national state of emergency was declared by the NZ government on the following day, 23 February 2011 and the declaration remained for 66 days [28]. The economic loss was very high as it was the most heavily insured seismic event ever recorded globally [29]. To support the recovery efforts, a central agency was established, Canterbury Earthquake Recovery Authority (CERA) on 29 March 2011. CERA was responsible for reconstruction and overall recovery of the city [23] as well as managing the red

zones. The use of PECs at such a large scale had been rarely observed prior to the Christchurch event, with exception of L'Aquila city, Italy. Cordons were gradually reduced over time (figure 1) and was finally lifted on 30 June 2013 after more than two years of being in place [14]. It should be noted that cordons were also placed in other parts of the city besides the CBD predominantly in commercial centers and buildings located in residential areas.

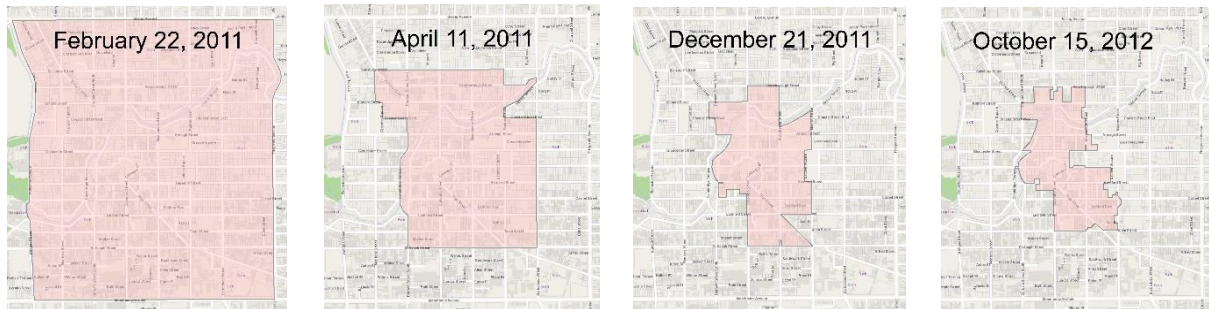


Figure 1 Evolution of cordons in Christchurch CBD (among 22 changes).

Source: Figures reprinted from [30]

2.2. L'Aquila, Italy

L'Aquila city is the capital city of the Abruzzo region in Central Italy. On 6 April 2009 a M_w 6.3 earthquake hit 34 km southwest of the city, at a depth of 10km. The earthquake followed a sequence of shakes ranging from minor to moderate that had begun four months prior with more than 10,000 localized events recorded during that time [31]. The main shock resulted in the deaths of 308 people, around 1500 injuries and damage to thousands of buildings [32]. Around €22 billion has already been spent on the rebuild and recovery of the city as of 2017 [33]. This cost was mainly directed to the historic city centre which suffered the most damage. A state of emergency was immediately declared, and red zones were setup with no access for the public. Although cordons were established in villages surrounding L'Aquila as well, the focus of this research is on the centre surrounded by the historic stone walls and multiple access gates. The red zones were reduced in size over the next decade (figure 2) but there still remains areas that continue to be red zoned as of May 2021.

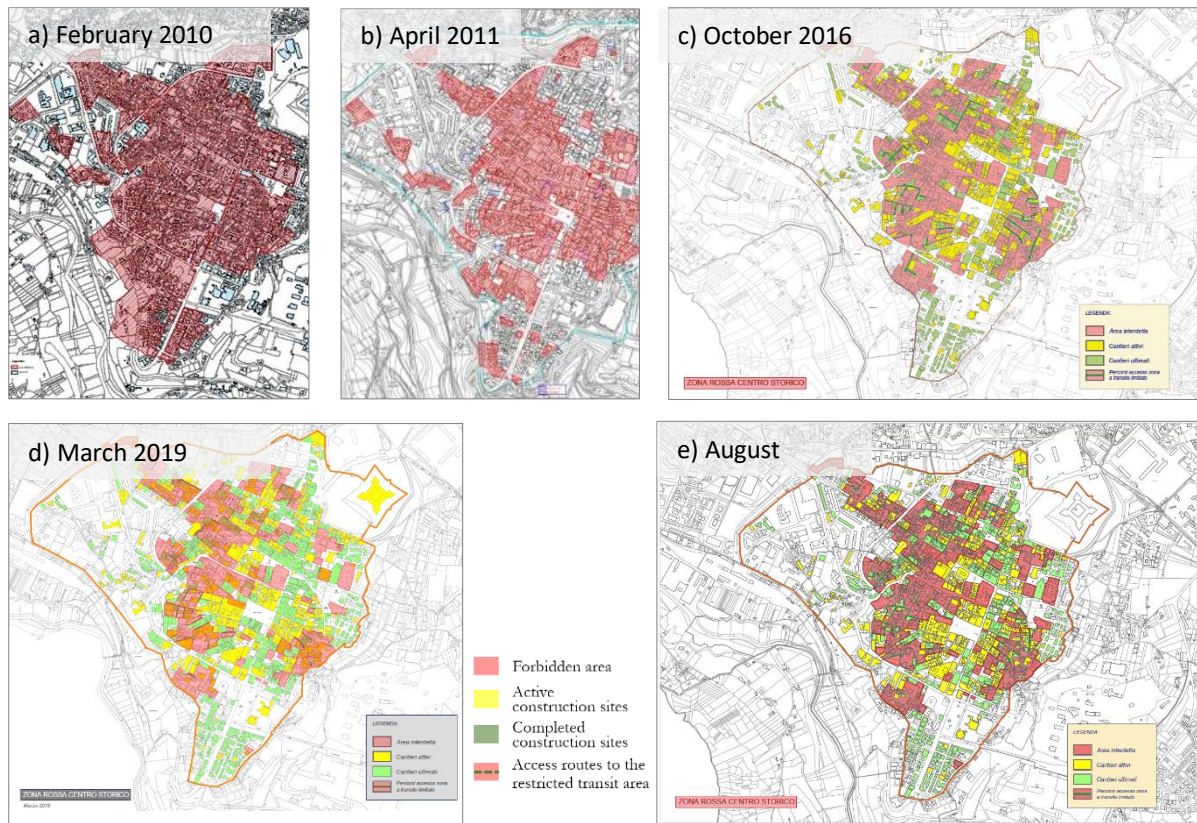


Figure 2 Evolution of cordons over the years in L'Aquila city

Source: a) [34] b)[35] c), d), e) [36]

2.3. Data collection and analysis

The data collection for this study was carried out by interviewing 23 key informants: 13 from Christchurch and 10 from L'Aquila between August 2018 and August 2019. Expert knowledge holders who participated in the research were from varying fields of expertise and included emergency managers, site engineers, council members, communication managers, police, academics and politicians. Their involvement and/or knowledge regarding the establishment and management of cordons and the overall response to the earthquakes was the primary criteria for their selection for this research. The interviewees were selected through purposive and snowball sampling and the interviews were conducted through a semi-structured questionnaire approach. The interviews in Italy were conducted in Italian by a native speaker from L'Aquila. Additional details about the participant's profession, nationality and corresponding interview duration are provided in Table 1. The interview data from L'Aquila was first transcribed into Italian and then translated into English. Then, both data sets were coded in the Nvivo software, grouped based on underlying themes and concepts and then analyzed inductively. This was done through open coding of the data to conceptualize initial categories [37] followed by axial coding to further refine the codes into distinct themes [38].

Table 1 Details of participant's profession and respective interview durations

S.N.	Profession	Total number	Avg. duration
Christchurch			
1.	Business Representative	1	47 mins
2.	Communication Manager	2	1hr 20 mins
3.	Council Representative	2	36 mins
4.	Demolition Manager	2	1 hr 57 mins
5.	Emergency Managers	3	1 hr 18 mins
6.	Insurance Representative	2	23 mins
7.	Police	1	47 mins
L'Aquila			
1.	Academic	1	1 hr 14 mins
2.	ANCE ¹ representative	2	41 mins
3.	Community Leader	1	1 hr 4 mins
4.	Council Representative	2	1 hr 13 mins
5.	Emergency Manager	1	1 hr 54 mins
6.	Engineer	2	50 mins
7.	Politician	1	1 hr 28 mins

3. Results and Discussions

The case studies showed that the initial demarcation of cordons is mainly defined by the degree of damage to an area and potential risk to people. However, if the scale of damage is huge, practical considerations are undertaken owing to existing physical demarcations, availability of resources and ease of planning. In Christchurch, initially, the grid pattern of streets in the inner city were cordoned off along four avenues that defined the area of worst damage (Figure 1), even though some blocks within the cordon did not suffer much damage. Similarly, the initial L'Aquila's cordon was demarcated by its pre-existing historic stone walls. In both cities, the spatial extent was gradually reduced once the risk had been mitigated.

From the thematic analysis it was clear that context was key to the set-up and management of cordons in both countries. As context evolved over time, so did the purpose of cordons. We will now discuss cordons in relation to two thematic timeframes; Phase 1 which relates to Safety/Law/Security and Phase 2 which is related to Recovery.

3.1. Phase 1: Safety, Law and Security

The primary purpose of establishment of PECs is life safety. This was observed in both Christchurch and L'Aquila where establishment of large cordons helped the respective authorities to significantly minimize citizens' exposure to risk. In the initial phase, owing to observed significant damage to built structures, cordons became necessary as the risk to life safety was apparent.

¹ ANCE is the Italian Association of private construction contractors which represents 20 regional organisations, 101 provincial associations and 20,000 construction companies in Italy. It safeguards the construction industry through engagement with political, cultural, social institutions and lobbying efforts. ANCE, L'Aquila was and still is, an important organization that overlooks reconstruction work in L'Aquila

'It was about removing risk and it was to make safe' – Emergency Manager, Christchurch

'It's an exceptional situation that doesn't allow people to enter (the city centre) because there is a risk to their safety' – Council Representative, L'Aquila

The cordons are also a tool to enable rapid access of first responders during the immediate response phase. In the aftermath of a major seismic event, significant search and rescue efforts become necessary as there are potentially large numbers of injuries and fatalities. A cordon allows emergency responders to act without potential obstructions from the public who may be in a state of panic and loss, or just curious to observe what has happened. Any potential delay caused by the public during the initial response significantly increases the risk to life for people trapped inside buildings awaiting rescue. If the number of deaths is high, then recovering the deceased becomes a priority.

'The initial reason to set it up was to limit obstruction for search and rescue and also to act as a deterrent for general public to enter the defined area' – Emergency Manager, Christchurch

The desire to establish PECs is also influenced by the legal frameworks that define the duties and responsibilities of the authorities following a disaster. This was evident in L'Aquila as the responsibility of people's safety after a disaster rested on the mayor. There is also a possibility of criminal liability on the mayor in case there are deaths and/or injury that could have been otherwise prevented after an event. There have been multiple cases in Italy where government officials have been prosecuted as one participant remarked:

'The Mayors have this enormous responsibility. The Mayor of Genoa is in jail for the history of the schools' – Politician, L'Aquila

The ex-mayor of Genoa, Italy had been sentenced to five years in prison for not closing the schools and roads despite a Level 2 Alert due to flooding in November 2011 that resulted in the deaths of six people [39]. Similarly, two government officials and five scientists were initially sentenced to six years in prison for communicating the risk of a large earthquake to be low, and thus reassuring residents a few days prior to the L'Aquila earthquake [40]. While all except one were later exonerated, the convicted government official received a reduced sentence of two years[41]. Potential liability for criminal offences for decisions taken that may cause harm meant that establishing a cordon becomes a safe and appropriate response tool as reflected by comment below:

'...because everybody knows that there is a time full of action and solidarity and a time when the judiciary appears. The two phases have different times and the second one comes always after, to blame you for something' – Council Representative, L'Aquila

Generally, in New Zealand, government employees have statutory protections from liability unless criminal negligence is found [42]. This allows government employees to work and take actions based on their judgement without the fear of prosecution later. However, it should be noted that legal actions indeed take place. A Royal Commission was setup after the earthquake, but its scope was limited to adequacy of building codes and standards of built environment around the Christchurch CBD [43]. Additionally, criminal investigation was carried out against engineers of the CTV building for gross negligence of its structural design resulting in collapse of the building and 115 deaths but ultimately the engineers were not prosecuted [see 43 for more details].

'We don't have any issues; we were under Civil Defence, and we were protected on this regard (regarding decisions)'-
Council Representative, Christchurch

While human safety is of the utmost importance, PECs are also established and/or maintained to secure the place against theft and vandalism. While crimes may increase [45–47] or decrease/remain stagnant [48,49] after a disaster, it is understandable that authorities would seek to reduce further disorder that may be caused by theft and looting in an already precarious situation created by the earthquake. The perceived risk of such crimes also informed the initial decision to establish the cordons.

'There is obviously quite a potential for looting which did actually occur even with the cordon in place. People were getting in and taking stuff' – Business Representative, Christchurch

'On top of that, other reasons for the cordon was, you know, security, there was still a lot of wealth, you had banks with sixty million dollars in cash with the vault doors are open. You had money just blowing around' – Council Representative, Christchurch

'A fence only keeps honest people out, okay. People were finding ways,..... they would climb over a series of people's houses and you can never stop that' – Council Representative, Christchurch

In both L'Aquila and Christchurch, interviewees discussed multiple cases of theft and looting. In L'Aquila, the true extent of looting is thought to have been overstated [50], which contradicts the accounts of the interviewees who remarked:

'...but it was needed since the Jackals² were taking away the little that had remained' – Council Representative, L'Aquila

'The Jackals! It was a dramatic problem that lasted for about two years' – Politician, L'Aquila

The differences in official counts of crimes and claimed number of crimes is likely due to the limited use of official data for reporting thefts, as well as potential under reporting, reduced or poorly managed record keeping, lack of resources (as police are busy with other urgent matters such as helping emergency managers and fire fighters for search and rescue operations, cordon management) in the aftermath of a disaster [45]. It is however clear that cordons can reduce the incidence of thefts and vandalism. This is highlighted in the study by [51] where researchers demonstrate the significant reduction of crime in Christchurch city centre from official data obtained July 2008 to June 2013. The researchers also note that almost 70% less crime observed in Cathedral square (CBD area) post-earthquake was spatially displaced to other parts of Christchurch.

To support establishing and maintaining cordons, in both cities, local police and army personnel were utilized. These officials helped with operational activities as well as kept the area secure. In Christchurch, the army together with the local council and emergency managers controlled the entry for public to retrieve their belongings. This was done through a comprehensive access program with photo ID as verification to enter the cordons. The residents could request permission to get into the cordons and depending on the risks involved, authorities allowed people

² Jackal, translated from 'Sciacallo' means a dishonest person who takes advantage of other people's tragedies, usually by stealing goods from their properties.

to enter, provided they were accompanied by fire fighters or emergency managers. The time allowed varied as one interviewee explained:

‘There was a cordon access program that was setup, and we would do that city block by city block. We would have the engineers to do the assessments and we would have the security and safety staff around so that it could be done and figure out what they were trying to do and work with them on some sort of agreeable time frames to get their stuff. In some cases, it was minutes and other cases it was hours’ – Emergency Manager, Christchurch

A similar system was also deployed in L’Aquila where authorized badges were used to verify one’s ability to access the cordons. Here too, residents were allowed to access their homes to retrieve their belongings, always accompanied by fire fighters.

‘These people were accompanied, they were authorized by badges and accompanied inside by the firefighters. So the firefighters accompanied these people to their houses so they could take what was possible to take’ – ANCE representative

One major difference observed between the two case sites is that, in Christchurch, the army did not carry any weapons whereas in L’Aquila, armed forces were deployed. It is possible that this influenced how the public perceived the role of army and the use of cordons over time. In Christchurch, the army as cordon managers were the face of emergency management and were respected for their efforts by the public [52]. However, the presence of armed personnel was not always welcomed in L’Aquila and for many locals were a cause of further distress [50].

‘It was especially the presence of the soldiers..... I mean, the red zone was making me feel very uncomfortable, but more than that it was the presence of the soldiers..... the constant presence of the soldiers was making me feel very uncomfortable because they were armed people that I was seeing regularly’ – Community Leader, L’Aquila

3.2. Phase 2: Recovery

As time goes by, the nature of the emergency changes as the urgency is reduced due to a reduced risk profile. This results in corresponding changes in response strategies adapting to new priorities and increased involvement of various organizations. However, in the case of earthquakes, due to the nature of on-going aftershocks, the risks may persist for an extended period (months to years) beyond the initial event. Tremors can further deteriorate an already damaged building into collapse. This directly affects the spatial and temporal extent of cordon placement [5] as illustrated by the following remarks from one participant:

‘I would say, prior to the June (2011) aftershock, I would have said we would be cordon free by October that year. That was probably what we had in mind, what we couldn’t knock down in time we would just isolate it. Later we realised that there was so much more work to do because buildings were even more damaged. Some buildings which had suffered only moderate damage in the earlier earthquakes but after the June aftershocks, they were completely damaged. The cathedral, more of the cathedral fell down’ – Demolitions Manager, Christchurch

In both cities, the damage to buildings was high and thus the risk of further damage to buildings and collapse remained for a long period of time. However, the recovery approach taken was governed by the contextual realities of each city. In Christchurch, the main damage was primarily observed around the central city which mostly hosted commercial and institutional buildings and fewer residential properties. The authorities focused on demolition of unsafe buildings as it was the quickest and most efficient way to reduce the risks posed by them. To this end, CERA had overreaching legal powers to demolish buildings that it deemed unsafe even without the consent of the owners of the building. Almost 1000 buildings were demolished within the Christchurch CBD by April 2012 [53]

'Demolitions within the four avenues was in the order of sort of 1600-1800 hundred buildings' – Demolition Manager, Christchurch

'So, at the start when it's about just saving lives or protecting, you know protecting people by getting a building down quick there's no questions asked' – Council Representative, Christchurch

This urgency for demolition in Christchurch was partly driven by businesses and homeowners actively opting for this option. This is because once a building was declared a total loss by insurers, the insurance settlement would be processed faster, which allowed owners more financial flexibility [5]. This was furthered by the fact there was growing uncertainty over the recovery of the city. People also wanted to get back to the city and a growing dissatisfaction among businesses resulted in demonstrations and breaching of cordons at one point [54]. The authorities did consider these pleas and worked together with businesses to facilitate the opening of the Re:Start³ shopping mall by prioritising demolitions on the access route to the mall.

'The government was really good in that respect. We needed to clear this street, so Re:Start sat where this building is right now, sat here and across the road. The government had to clear all the roads and all the dangerous buildings, and they had to get it done quickly so we could Re:Start' – Business Representative, Christchurch

The cordons assisted in demolition works in multiple ways. Since the public could not get in, the demolition contractors could work faster without worrying about risk to bystanders. In essence, the space within the cordon worked as a giant construction site. Additionally, there was no unauthorized vehicular movement leading to minimum traffic which also allowed for larger roads and vacant lots to be used for storing demolition debris, construction materials and large vehicles. Because access points into the cordons were controlled and records kept with regular monitoring, it also became easier to keep track of demolition and construction works which was useful for avoiding other potential hazards such as asbestos poisoning, as one interviewee explained.

'And the other purpose of the cordon that we used it for was waste in and out of the waste stations and check it, washing bays, to see where it is going so that it does not go into the water because people were worried about the asbestos that is being trucked down from the centre of the city' – Demolition Manager, Christchurch

A Christchurch simulation study conducted by [55] showed that the asbestos exposure due to demolition and home remediation was well below the standard exposure permissible in workplace. However, the concerns regarding potential asbestos poisoning were evident throughout the demolition process. Cordons also presented an opportunity for businesses/homeowners to undertake repair, retrofit or redesign work on their buildings even if there was limited or no damage to them as the cost of doing operations within the cordon was significantly less compared to normal times. This was assisted by reduced administrative processes and costs related to getting permits and approval from the council.

'Because inside the cordons they could work in a far accelerated rate. So, if you have a broken building and you got to repair it and deal with public traffic and pedestrians and access and resource consents and all that, normally it can take years to get started.... So, some of the business owners pretty quickly figured that out that they can use the cordon to their advantage and speed up the recovery and maybe it did. It accelerated some of the rebuild by years' – Emergency Manager, Christchurch

³ Re:Start: It was a temporary shopping mall built from shipping containers which accommodated 27 shops. It was opened on 29 October, 2011 and remained opened until January 2018.

While the presence of cordons assisted in demolition and rebuilding works thereby supporting recovery of Christchurch city, it also presented challenges. One major issue was around insurance. New Zealand is one of the few countries in the world with high uptake of private earthquake insurance. Around 98% of buildings (residential/commercial/offices) in Christchurch had insurance coverage[56] when the earthquake hit, thus making it the highest insured seismic event in history [29]. While there were many issues surrounding insurance (see [57,58]), cordons created or exacerbated the situation for insurers, claimants, and the authorities. Firstly, during the initial phase there were instances where neither the insurers nor homeowners were duly consulted before demolitions were carried, citing safety concerns, despite opposition from the owners and insurers. This complicated the situation as insurance coverage was only activated from damage caused due to the earthquake i.e., it did not cover the damage caused due to the action of the authorities. Since the demolitions were enforced by the authorities, it was debated by the insurers that the subsequent damage did not fall under the earthquake insurance coverage. The complexity of the situation is described by the insurance representative as follows:

‘From an insurance perspective, is there material damage or not to properties within the cordon? And then there is the interruption to business within that cordon and what triggers the business interruption relief which may well be dependent upon the material damage or not to the building. And the decisions that are made around which buildings are demolished, when they're demolished, what level of consultation or no consultation is provided to the business, to the owner of the property, or to the tenants of the property who have businesses that are demolished without any consultation whatsoever. And then they have difficulties making claims because the damage was done by the authority and not by the earthquake and they took an insurance policy for earthquake cover’ – Insurance Representative, Christchurch

‘Virtually all insurance policies covering property, there are exclusions and one of the common exclusions around the world is acts of civil authorities’ – Insurance Representative, Christchurch

Furthermore, cordons also created situations where the building in question was not damaged but was placed within the cordon due to the risk posed by neighbouring structures. Again, ‘damage’ which usually triggers the insurance claim (unless there was a specific clause stating ‘loss of access’) was not observed. This inability for owners to access insurance because their building was not technically damaged, resulted in disputes. People with coverage for business interruption also faced similar challenges to claim for loss of earnings and business disruption. Additionally, tenants of the buildings also faced multiple sets of challenges as most leases are different from one to another which complicated the situation. Also, claims made by the tenants would generally be processed once the landlord and landlord’s insurer came to a mutual understanding about the fate of the building [58] which meant that there was a lot of uncertainty for the tenants for a long time. It should be noted that, in part, large scale demolitions in the CBD eased the situation for business interruption claims [5] as the claims shifted towards damage of buildings.

‘Well, its owners signing agreements with the Crown to put the Crown to take control and take those (demolition) works. We did that most of the time by mutual agreement. There's a few that was not a mutual agreement. We still took control of that because it impacted on cordon reductions and the neighbours’ – Emergency Manager, Christchurch

Secondly, even when there was clear damage to buildings in question, it was difficult for claimants as well as insurers to conduct an assessment of damage because access within the cordons was tightly controlled. Additionally, there were limited resources initially as hundreds of thousands of

claims were registered which neither the private insurers nor the EQC⁴ had the capacity to process [57]. As such, the process of claiming damages and being compensated was long and arduous. The complexity of the whole situation is highlighted by the fact that there are still hundreds of cases which are yet to be resolved more than a decade later [59].

'So, the insurer can't inspect the damage. (Yeah) Well that will slow the process. So, the insured has no access, so the insured has difficulty making a claim as to what the losses are' – Insurance Representative, Christchurch

'Well, the demolition sort of hinged on people getting their insurances sorted out too. So, you know, if there is a dispute about a building, it could or could not be repaired, umm, that could take time. That is why there was that hold up. If you'd had, let's say, a whole sort of, we are pulling everything down and blow the insurance, it would have been a lot faster. But of course, they have to all work with their insurance processes individually with their insurers. Some of them argued' – Business Representative, Christchurch

In contrast to New Zealand, Italy is significantly underinsured against earthquakes. With a penetration rate of less than 10% [60], insurance did not play a significant role in relation to PECs. However, L'Aquila has faced multiple challenges of its own due to contextual realities that have persisted till this date. The fact that cordons still remain in some parts of the historic centre at the time of writing is a reflection of the complexity associated with use of cordons and overall recovery of the city. The first challenge emerged with the decision to establish the cordon itself. As the city centre was a residential area, around 70,000 people needed to be evacuated immediately from the dangerous red zone and required temporary housing. Approximately one third of evacuees found accommodation by themselves, another third were sheltered in state-sponsored hotels and the remaining third in temporary camps (tents) [61]. After a decade, there were still over 10,000 people in temporary accommodation [50]. The complications of managing immediate (and temporary) housing needs after a disaster have been discussed thoroughly in the literature [62–65]. The recurring issues of cultural insensitivity, delays, inappropriate location, environmental unsuitability, economic sustainability and construction quality were compounded by the command-and-control approach of the military which exacerbated the discomfort and discontent of L'Aquila residents [50]. There was lower demand for temporary housing in Christchurch [66] as the city centre primarily accommodated businesses and few residents. This meant that the significant housing challenges experienced in L'Aquila were avoided in Christchurch. Nevertheless, temporary housing after a disaster is a complex issue and a potentially unavoidable reality if PECs are to be established for a long time where residents live as illustrated by comments from one of the participants:

'After I signed that document, about 75,000 / 80,000 people, considering also university students, became evacuees' – Politician, L'Aquila

Many buildings in L'Aquila were significantly damaged but did not fully collapse. Although demolitions of such buildings were carried out for a short period of time in the beginning, the focus was always on protecting the historic buildings and cultural heritage. Then, one of the first steps was to ensure the stability of the buildings by shoring⁵ to protect against further damage and to minimize risk for emergency managers, fire fighters and the police to carry out their operations.

⁴ EQC as in the Earthquake Commission is a New Zealand Crown entity that provides insurance to residential property owners and also invests in natural disaster research.

⁵ Shoring of buildings: It is an engineering process to temporarily support damaged buildings against collapse usually done through timber or metal props.

In this case, however, the Cultural Heritage Commissioner made it compulsory not to demolish anything, because they were all historical places so even the bell tower was unstable, still it was a XVII-XVIII century bell tower with decorations. Therefore, we had to intervene in critical conditions, even extremely critical precisely because demolishing was forbidden, the building had always to be saved even if it was extremely unstable' – Engineer, L'Aquila

'If there is a restricted building where you are not allowed to demolish, if you leave it in those conditions, not only it becomes a danger and you can't, you can't enter it, this applies even to those who are in the red zone, to the firefighters, and we had to move anyways when we wanted to visit and if we wanted to move we had to secure as we were moving forward' – Engineer, L'Aquila

Shoring of buildings was done in stages and it changed over time in terms of the methods and materials used. Initial shoring was done by the firefighters, and mostly consisted of wooden structures as provisional support systems. The required shoring was at such a great extent [67] that, to facilitate it, a special unit was developed called the Coordination of Provisional Works (NCP) within the national fire department (CNVVF) [68]. Although, limited in its strength and durability, the initial shoring systems in place allowed fire fighters and other relevant personnel to access the red zone and carry out the initial disaster response activities. As buildings were being secured, it allowed the authorities to reduce the spatial extent of the red zones as explained by the authorities:

'The first safety measures were made by the firefighters who used wood, but wood does not guarantee durability, but well, they could not do more than that at that time' – Council Representative, L'Aquila

'As long as the shoring was done, I was making the red zone smaller, but of course, the shoring had to be done first' – Politician, L'Aquila

The shoring of buildings also brought its own challenges. The initial shoring was done without pre-planning and often done invasively which meant that removing them without affecting the structural integrity and/or architectural heritage became difficult. Subsequently, given the complexity of damage to buildings and an array of building failures at a large scale across the city, initially, there was dearth of engineers with the necessary technical skills and capacity. To overcome this challenge many agencies such as Civil Protection, Universities and Ministry of Cultural and Architectural heritage, along with the fire fighters collaborated to design, develop and implement an alternative urban shoring system. Over time, however, it became difficult to coordinate these efforts [68]. The lack of public oversight for contracting the shoring activities to various companies [69] also highlighted the issues of transparency and potential corruption. However, the upgraded metal shoring systems were more secure and durable, as evident by the continued use of these systems at the time of writing. Even when the main structure was secured, there is still a possibility of non-structural parts falling which meant that the risk was not completely averted. Further challenges arose in maintaining the shoring systems in places which required technical and financial resources which were not always available.

'Or maybe the same company that followed that specific shoring system isn't there anymore because it was responsible for it only for a temporary moment for that specific shoring and not for others and it's very likely that some companies aren't participating in the reconstruction anymore, they set up the securing and they left, which is quite common' – ANCE Representative, L'Aquila

'Because the problem following the shoring was not the collapse of the building, but rather the detachment of parts of it. Therefore, we just had to monitor that it was all right, we had no concern that the building could fall on the road' – Council Representative, L'Aquila

The shoring system nevertheless supported the reconstruction process by allowing a safe working space for reconstruction to begin and continue. Similar to Christchurch, the red zone was a transitional space that was free from logistical obstacles and had simplified bureaucratic processes which allowed physical and administrative works to be carried out faster. PECs also provided a less stressful environment for the construction workers by eliminating the presence of the public. Furthermore, it also supported the finances of the reconstruction projects through fee waivers of large sums of money for occupying public land (street such as via dell' Arcivescovado and plaza such as Santa Maria Paganica) necessary to setup a construction site.

'The shoring issue was useful because knowing the Italian timing, the reconstruction of this palace ... for example started after 7 years, after 7 years if you don't shore this up, it continues to open up and grow more and more until it collapses as it happened in some cases' – Engineer, L'Aquila

'It was much better for the businesses to work when there was the red zone, because it meant that only businesses could enter, and we had all the space we needed to set up the construction site' – Engineer, L'Aquila

'For the workers, yes, because the work was limited to an area of a building that he knew was free from other people, only the ones linked to the construction site. Imagine, if, in such a vulnerable area with narrow streets it was possible to have children or old people it would be an aggravating circumstance from the point of view of risk and safety. Let's imagine a crane truck which is installing a steel beam as security system but there's a child with his grandfather in the nearby' – ANCE Representative, L'Aquila

'When the red zone was here, they didn't pay for the public land, now in a normal situation they are really working like any other city in the world, so they pay for the occupation of public land and it's extremely expensive, like here they can pay €100.000 euro for two years. It is a cost in the reconstruction' – Engineer, L'Aquila

It should be noted that in both cities, authorities wanted to bring people into the city as soon as possible. To this end, the Christchurch red zone bus tours [70] and opening of the Re:Start shopping mall were attempts made by authorities to bring the public back to the city centre. Similarly, in L'Aquila some businesses and bars were given temporary permits and few Piazzas were opened so that the citizens could have some degree of social life. The desire to reduce PECs and return life to normalcy will always be there. And even when safety is of limited concern, the reduction of cordons may be dependent on administrative, technical, and resource challenges. As observed in L'Aquila, the rebuilding of the city has been an extremely complicated process [69]. The private reconstruction has been prioritised over public buildings to enable citizens to get back into the city as soon as possible, yet the completion rate for reconstruction is still low considering it has been more than a decade since the earthquake disaster. This has caused a lot of discontent among the citizens of L'Aquila.

'But they go with two very different speeds: we have reached between 70% and 75% of the private reconstruction, while with the public we are generally at 10%, considering the whole seismic crater⁶ and not only the city of L'Aquila' – ANCE representative, L'Aquila

'Human and social times are different from construction times, from administrative ones' – ANCE Representative, L'Aquila

As discussed above, PECs and their purpose evolve from their initial, safety focused, police/army controlled red zone into a transitional space focused on reconstruction and are sensitive to people's

⁶ Seismic Crater denotes broader areas affected by the L'Aquila earthquake. It contains 57 municipalities of which 42 are from L'Aquila province, 8 are from Teramo province and 7 are from Pescara Province

wellbeing. Accordingly, people's perceptions and acceptance of PECs also evolves as described by one participant below:

I think that the acceptance of the red zone and today's barriers are two very different things, in the sense that ... because when you are told that that thing is a red zone and you are outside the red zone and there are soldiers and you live elsewhere and you don't know if you will come back to live in L'Aquila, if a reconstruction will ever start, you think the red zone will be forever. Today we hardly notice it anymore because even though the red zone is still there, it seems that it doesn't exist anymore, because we go everywhere. The 'barriers' are gone, the soldiers are gone' – Community Leader, L'Aquila

Considering the impacts of cordons in both case studies, it can be argued that establishing and maintaining cordons have had a positive effect on recovery of these cities. In case of Christchurch, this conclusion has been supported by other studies as well [21,58]. However, it is difficult to ascertain to what degree PECs were influential in supporting recovery and even more difficult to conclude if PECs were appropriate (for such a long time) given their overarching imposition over various aspects of people's lives and livelihoods. Undoubtedly, PECs are useful, but by virtue of their restrictiveness, they can be detrimental to civil liberties [71]. It is understandably controversial to exclude people from their own homes, own streets, own city for an extended timeframe (years) when that geographic area is not perceived to have risks. If the awareness of risks differs, then there will be observed differences in the public's willingness to accept those risks, which might be in contrast/conflict with the degree of risk that the authorities deem appropriate to allow. As such, it is necessary to properly communicate the actual risk posed by the buildings within the cordons so that varying perceptions of risks among the public and the authorities can be aligned.

4. Conclusion

Post-earthquake cordons are a necessary response tool to ensure the safety of people against risks posed by structurally unsafe buildings as well as non-structural elements that may fall due to aftershocks. However, as the level of risk subsides the continued presence of cordons can have a range of potentially unintended consequences, both positive and negative. Nevertheless, this research has demonstrated that cordons can evolve from being a safety-focused response tool to reconstruction-focused transitional tool. To this end, it is necessary to understand that, even though there are similar factors driving PEC establishment, it is equally important to recognize that the contextual realities of each case will undoubtedly affect how cordons are managed and how they impact response and recovery. As observed from the two case studies of Christchurch and L'Aquila, insurance, recovery strategies (demolitions vs shoring) and temporary housing needs are some of the major context-driven realities that directly affect PECs and their extended establishment. Effective communication about PECs will foster understanding of the reasons why PECs are necessary, initially, for life safety purposes and later, can be beneficial to support recovery over extended time periods.

5. Ethics Statement

The University of Otago Human Ethics Committee has approved this study under category 'A'. Excerpts from the interviews are anonymized for privacy.

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8. Appendix

The following are some of the general questions that were asked during the interviews.

Time frame	General Questions
Short-term	<ul style="list-style-type: none"> • Who took the decision to establish initial cordon/s? • What were the underlying reasons for the decisions? • What type of information is necessary during initial cordon establishment? • What were the major challenges during the initial period of cordon establishment and management?

Mid-term	<ul style="list-style-type: none"> • The cordon was reduced gradually [in Christchurch]. What were the major considerations taken for reducing cordons? • How did the extended timeframe of the cordons impact businesses, transport, and temporary housing? • Was the extent and management of cordon flexible? Could it have been more flexible, both in terms of the spatial extent and access? • How was the information related to cordons communicated to the public? Do you think the public should be involved [if so, when?] in decision making and cordon implementation? • What type of information do you need for effective cordon management during this timeframe?
Long term	<ul style="list-style-type: none"> • How did the cordons impact recovery of the city? • What was the effectiveness of the cordon, especially if you consider the long-term implications? In hindsight, was having the cordon in place for such a long period necessary? • Do you think cordoning should be a part of a disaster recovery framework?