NEW ZEALAND FIRE SERVICE COMMISSION
Whakaratonga Iwi

Fire Research Report

THE PREVALENCE AND FIRE SAFETY IMPLICATIONS OF EARLY CHILDHOOD CENTRES IN MULTI-STORY BUILDINGS

May 2015

BRANZ Inc.

Early childhood centres (ECC) are increasingly being located in multi-story buildings. This report indicates that between 50 and 80 ECC have children located above ground floor level, and NZ Fire Service is interested in the regulation of these centres for fire safety. International practice for these centres was examined and generally New Zealand regulation compares quite well with overseas jurisdictions. The main concern is with fire drills. Advanced notice trial evacuations are not necessarily a realistic model for what could happen in an actual fire. The report recommends more realistic evacuations should be run to identify any potential problems with equipment, training and procedures. Some recommendations are also made about fire design and location of ECC which would require changes to the building regulations.

Please note:

This report contains commentary and interviews with New Zealand Fire Service Commission staff. The views and opinions expressed by them do not necessarily reflect the views, opinion or official policy of the New Zealand Fire Service Commission or any related organisation

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1. EXECUTIVE SUMMARY

BRANZ was commissioned by the New Zealand Fire Service (NZFS) to consider:

- The number and trends in the number of Early Childhood Centres (ECCs) located in multi-story buildings, and particularly where children are located upstairs.
- What is international best practice on evacuation regulations for ECCs in multi-story buildings.
- What, if anything, New Zealand should do to improve regulation related to ECCs in multi-story buildings to ensure safe evacuation in the event of a fire or other emergency.

The prevalence of ECCs with children upstairs in multi= story buildings

The study estimates that between 51 and 83 ECCs in New Zealand are likely to have children located above the ground floor, or up to around 1.7% of all ECCs. These ECCs are almost all within Auckland and Wellington's CBDs with their high employment densities. Over the next several years, the number of ECCs with children located upstairs is expected to grow, to between 61 and 117 by 2030.

International best practice and the New Zealand regulations

Our analysis of international best practice and discussions with New Zealand firefighters indicated that our regulations compare quite well with comparator nations.

That said, there was significant concern that staged trial evacuations were not a realistic reflection of the likely conditions for an actual evacuation. For instance, ECCs arranged for more adults to be on site. Thus while the regulations may be in place, in practice the current regime may not go far enough.

Recommendations to reduce risk

The main recommendations are:

- ECCs be restricted to no higher than the 4th floor (where the ground floor is level 0).
- Places of safety for new ECCs be positively pressurised to mitigate against smoke entry.
- Consistent design criteria be used for developing and evaluating evacuation schemes, including specified evacuation travel speeds, factor of safety and child carrying capacity of staff. This requires changes to the Verification Method 2 in Clause C of the Building Code.
- Approval for a new ECCs to become operational should be conditional on NZFS observing and approving a trial evacuation. Final approval of the evacuation scheme is to be required within six months of opening.
- NZFS and MoE jointly observe at least one unannounced evacuation a year of all occupants of a building with ECCs to help identify any safety issues.

2. INTRODUCTION

BRANZ was commissioned by the NZFS to consider:

- The number and trends in the number of ECCs located in multi-story buildings, and particularly where children are located upstairs.
- What is international best practice on evacuation regulations for ECCs in multi-story buildings.
- What, if anything, New Zealand should do to improve regulation related to ECCs in multi-story buildings to ensure safe evacuation in the event of a fire or other emergency.

2.1 Defining ECCs

Using the broadest definition of an ECC, there are an estimated 4,990 to 5,100 ECCs in New Zealand.

A number of data sources were used to estimate the total number of ECCs in New Zealand, and within this group, the number of ECCs in multi-story buildings. Even more narrowly defined, the key focus was ECCs in multi-story buildings where **children are upstairs**, making evacuation more difficult.

Using the broadest definition of an ECC, there are an estimated 4,990 to 5,100 ECCs in New Zealand.

The NZFS is interested in this question because of a desire to evaluate the adequacy of current fire safety regulations for ECCs. Ultimately it aims **to prevent injury and death** in the event of a fire or other emergency requiring evacuation.

The perspectives of other agencies that collect data on ECCs are different. Statistics New Zealand (SNZ) is concerned with the number of viable businesses operating and their resultant employment. The Ministry of Education (MoE) focuses on the provision of quality education and care by registered providers.

In contrast, the NZFS focus must be on the **broadest definition of ECCs**. In short, this study aims to estimate the total number of regular, organised gatherings of pre-school aged children. Within that, it aims to estimate the number that are likely to be in multi-story buildings where children will need to descend at least one floor in the event of an emergency. It further aims to consider the changes in the number of these regular, organised gatherings in multi-story buildings over time.

2.1.1 What is included in the broad definition of ECCs?

The MoE collects a wealth of information on ECCs of various types and legal descriptions. We briefly introduce the different types of ECCs here. The focus is on:

- How many are there.
- What age the children are (the younger the child the less mobile).
- Who runs the ECC (which may have implications for communicating safety regulation information).

Data on **licensed ECCs** (all ECCs other than playgroups) is more comprehensive than for **playgroups**, which tend to be less formally structured. Throughout this analysis, we refer either to "**all ECCs**" or "**licensed ECCs**" as appropriate. ECCs include:

- **Education and care centres**: Licensed by the MoE, these centres offer all day or part day services. These include casual centres, such as those in shopping malls and gyms, where children stay only for a short time while caregivers are at the venue, and church-based or workplace-based centres. This is by far the biggest group in the MoE database, with 2,321 of these registered in the June 2013 year.
- **Playgroups**: Not to be confused with playcentres (see below), playgroups are community-based groups that give parents, whānau and caregivers the opportunity to meet together and provide play programmes for their children. To be a playgroup, more than half the children attending must have a parent staying with them. They are not licensed ECCs like the other types of ECC described here. The playgroup sessions are often set up in community halls where equipment is put out before each session and cleared away afterwards. There were 845 registered playgroups in New Zealand in June 2013.
- **Kindergartens**: Kindergartens are licensed by the MoE, and are run by a kindergarten association. Each kindergarten is run by a committee made up of parents and people from the community, which reports to a local kindergarten association. In June 2013, the MoE recorded 643 kindergartens.

There are several categories of licensed ECCs in New Zealand, as well as playgroups, a separate category that is not licensed by the MoE.

- **Te Kōhanga Reo**: These are licensed by the MoE, and are parent-led services with a focus on building knowledge of te reo Māori (language) and tikanga (culture). Children can attend from birth, and parents and whānau are responsible for the management and operation of the ECC. In June 2013, 465 of these ECCs were registered.
- **Playcentres**: Parents, whānau and caregivers together run the centre licensed by the MoE. Playcentres offer learning through play for children from birth to school age. In June 2013, there were 447 registered playcentres in New Zealand.
- **Home-based centres**: These licensed services involve an educator providing education and care for small groups of up to four young children in a home setting (theirs or the child's). The most well-known example of this type of centre in New Zealand is PORSE. In total, there were 348 registered home-based centres in June 2013.
- **Hospital-based centres**: There were 12 licensed ECCs linked to hospitals in New Zealand as of June 2013.
- **Casual education and care, and correspondence school**: There were 19 of these services licensed by the MoE in June 2013.

3. SCALE AND GROWTH OF ECCS IN MULTI-STORY BUILDINGS

This section estimates the number of ECCs, how many are in multi-story buildings, and how many ECCs operate in an environment which requires children to be upstairs.

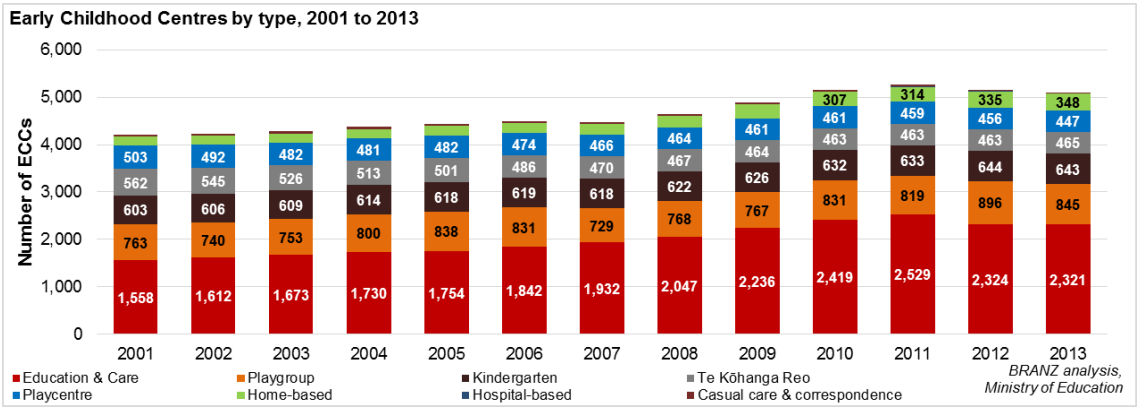
3.1 How many ECCs are there?

As already mentioned, there are several different data sets that can be accessed that give some idea of the total number of ECCs, but they tend to offer quite different results. We examine some of the key datasets here before narrowing our focus to an estimate of the number of ECCs in multi-story buildings.

3.1.1 Ministry of Education data by ECC type

Figure 1 shows changes in the number of ECCs of the various types since 2001 according to MoE data.

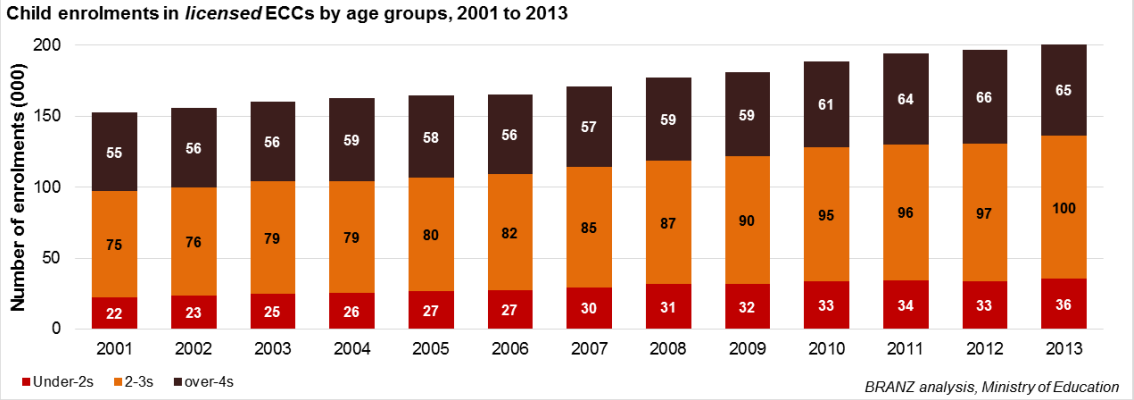
Figure 1 The number of ECCs has grown by 21% in 12 years



The fastest growth has been in the number of home-based ECCs, growing by 89% over 12 years, from just 184 in 2001. In absolute terms, education and care centres have seen the biggest rise, with 763 more centres in 2013 than 12 years earlier. There appears to have been a classification change in 2010, with a decline in the number of casual care centres and a commensurate increase in the number of hospital-based ECCs.

The growth in the number of children enrolled in ECCs has been even faster than the number of ECCs, as shown in Figure 2. However, this analysis is limited to licensed ECCs because of a lack of data on child numbers at playgroups.

Figure 2 Enrolments have risen 32% in 12 years, led by the least mobile under-twos



The number of children at **licensed** ECCs has grown by 32% in 12 years, compared with a 23% growth in the number of **licensed** ECCs in MOE data. Around half of all enrolled children are aged two or three. The **far less mobile** children aged under two numbered nearly 36,000 in 2013. This youngest group has also recorded the largest growth in enrolled child numbers over the last 12 years, with 59% more under-twos in ECCs in 2013 than in 2001.

3.1.2 Statistics New Zealand data on pre-school geographic units

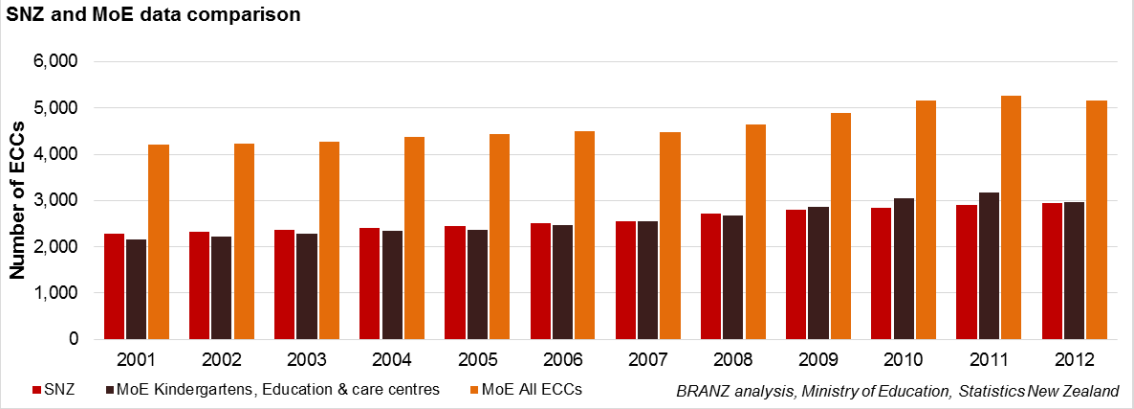
We also examined SNZ business demography data on the number of preschools, and the associated number of workers at those preschools. This analysis served three purposes:

- It provided a cross-check with MoE data.
- It allowed us to monitor changes in the number of paid staff at each ECC, an indication of the change in scale of those businesses.
- It provided the basis for estimating child-caregiver ratios.

The first thing we noticed was that the SNZ data yielded far lower estimates of ECCs than the MoE data. This is probably because the SNZ focuses on businesses with annual sales subject to GST of more than $30,000, or over $40,000 of income recorded in the IR10 annual tax return. This would exclude playgroups, and most other parent-led groups including many playcentres, home-based centres, and Te Kōhanga Reo. Hospital-based centres are likely to be captured under employment in health services rather than pre-school education.

In other words, the **coverage of the SNZ data is likely to be limited to predominantly education and care centres, and kindergartens**, as suggested by the comparison of data in Figure 3.

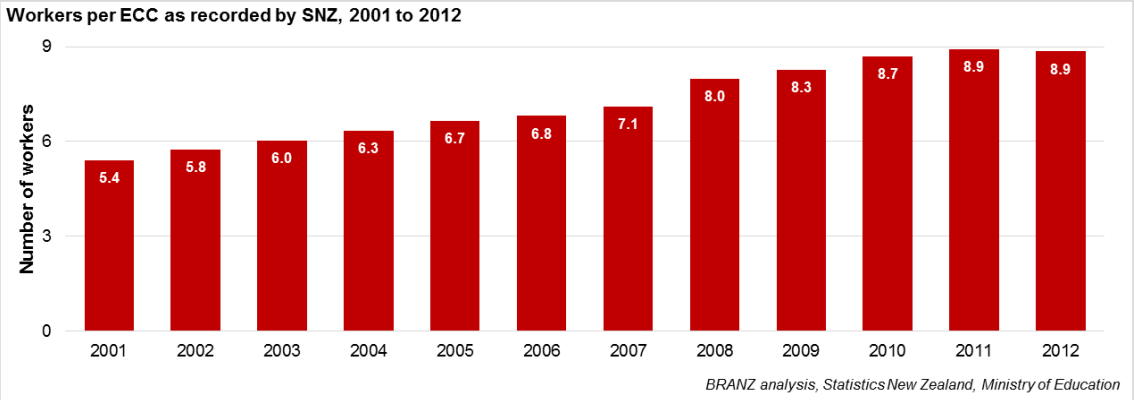
Figure 3 SNZ data differs from MoE data significantly



The implication is that the SNZ data is less useful for the purposes of estimating the number of sites at which pre-school children are regularly grouped in a formal setting. Nevertheless, it is encouraging that it closely tracks the two MoE categories that are most likely to be captured as businesses in the SNZ data collection process.

However, the SNZ data can be used to track the **changes in the number of staff members in ECCs** over the last 11 years. This reflects the big changes in child enrolments especially as 20 hours of government-funded early childhood education (ECE) was introduced in the late 2000s. These changes are highlighted in Figure 4.

Figure 4 The number of workers per ECC has grown sharply



The number of workers per ECC captured by the SNZ data has risen from 5.4 in 2001, to 8.9 in 2012. Most growth occurred between 2007 and 2010 as the number of young children in ECE rose sharply. Given that the number of children per worker has changed far less, this indicates significant growth in the average number of enrolments per ECC.

The number of workers per ECC of the types captured by SNZ (assumed to be mostly Education and care services, and Kindergartens) is surprisingly large. This indicates that in the event of an evacuation emergency, there may be a significant number of adults on hand to assist.

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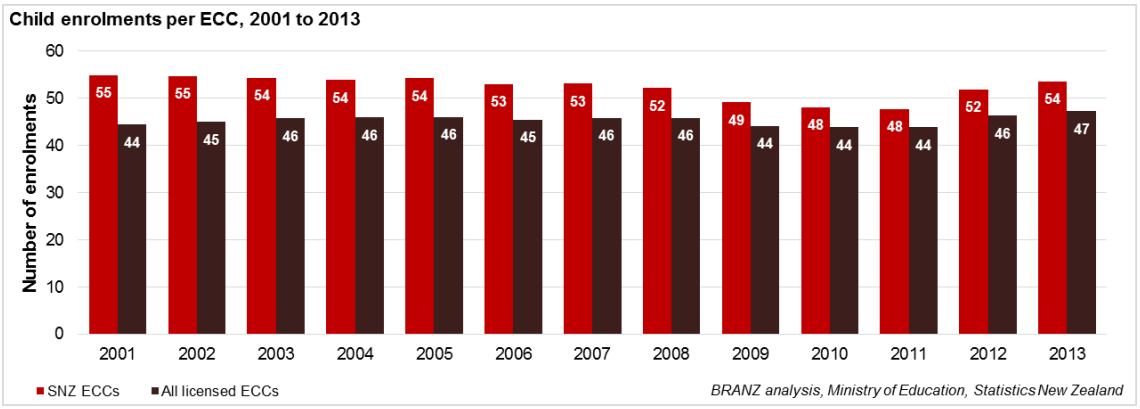
3.1.3 Children per ECC and children per worker

The average number of children per ECC has not changed dramatically, as Figure 5 highlights.

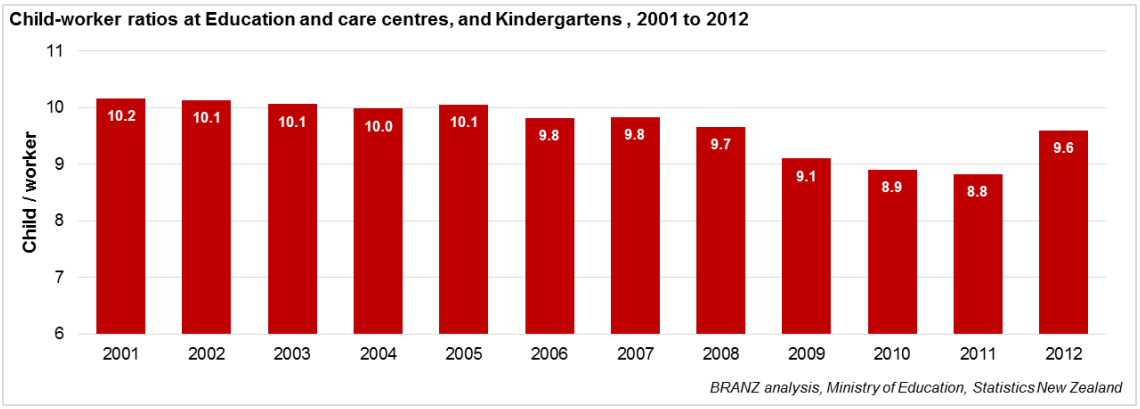
Figure 5 Child enrolments per ECC have remained relatively steady



Looking only at Education and care centres, and Kindergartens (which align most closely with SNZ data), the number of children per ECC has remained at around 54. Looking at the wider group of **licensed** ECCs, the average number of enrolled children has risen from 44 to 47 children per ECC.

From a safety perspective, an important consideration is the child-worker ratio at ECCs. Complete data on the number of workers at the full range of ECCs as defined by the MoE is not available. Assuming the SNZ data on number of businesses and employment refers to Education and care centres, and Kindergartens given in the MoE data, we are able to observe some trends. Figure 6 highlights these trends.

Figure 6 Child-worker ratios have improved slightly since 2001



The number of children per worker has fallen slightly, from around 10.2 in 2001, to a low nearer 8.8, before rising slightly again to 9.6 by 2012. For evacuation purposes, this means on average each worker would be responsible for around 10 children. We are not certain how to interpret this in light of the MoE child to staff ratios of 5:1 for under 2's and 10:1 for over 2's. It is likely that some staff have been recorded under different industries such as health and finance/ insurance where ECC are located in hospitals and offices.

However, other possibilities include that not all children are on site at all times. Some parents may only work mornings or afternoons, meaning their children are enrolled at an ECC but not always there. Another possibility is that some ECCs have unpaid volunteer or parent assistance, meaning the ratio of paid workers (captured by SNZ data) to children is lower than the adult to child ratio.

3.2 How many ECCs are in multi-story buildings?

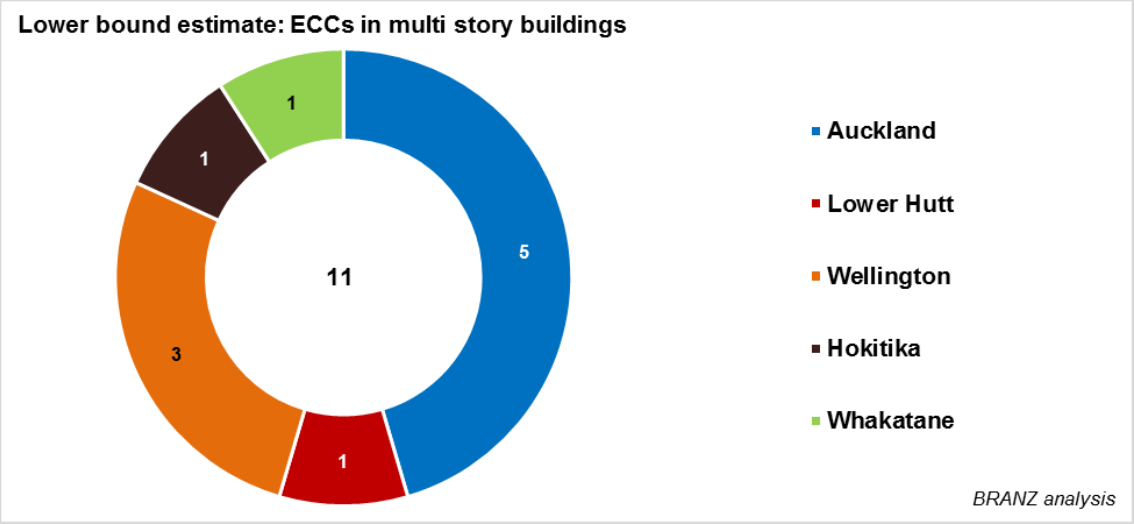
One of the key questions for this study is to estimate the number of ECCs that are in multi-story buildings, and specifically, where there are children located upstairs. We conclude that there are **probably around 80 to 85 ECCs** located in multi-story buildings where children would need to navigate stairs in the event of an emergency.

3.2.1 An initial approach to estimating ECCs in multi-story buildings

The MoE dataset includes addresses of more than 4,000 licensed ECE services and more than 900 playgroups. This dataset has some double-counting, which we removed. It also includes some services that appear to be office sites that do not have children onsite, such as offices for au pair or "nanny" services.

Filtering out these entries leaves 4,057 licensed ECE as of June 2013, and 936 playgroups. Scanning these 4,057 facilities for any that have addresses that include the words "Level" or "Floor" provides a base estimate of the number of ECCs in multi-story buildings. This estimate is set out in Figure 7.

Figure 7 A lower bound estimate of the number of ECCs in multi-story buildings



This estimate shows only 11 ECCs in multi-story buildings, of which five were in Auckland and four in Greater Wellington. Surprisingly, two of the ECCs were in areas not commonly thought of as built-up – Whakatane and Hokitika. This suggests that because a multi-story could be only two floors high, the potential number of areas with multi-story ECCs could be far larger. All 11 ECCs that appear to be in multi-story buildings are of the licensed types, with no playgroups recorded as being in multi-story buildings by searching for the words "Level" or "Floor".

3.2.2 Alternative approaches to estimating ECCs in multi-story buildings

The particularly low number of ECCs identified as being in multi-story buildings under the approach above was surprising, at just 0.22% of all ECCs for which we have data. For instance, one would expect that in relatively built-up urban areas, even purpose-built ECCs may well be multi-storied. Even though an address may be given as a simple street address, it may well be in a multi-story building, and is therefore not captured by the lower bound approach.

An example of this is the TVNZ Educare Centre. Its address is given in the publicly available MoE database as 100 Victoria Street West, Auckland, which gives no indication that the ECC may be in a multi-story building. However, a quick review of the address on the internet shows that it is indeed a multi-story building. This made it obvious an alternative estimation technique would be required.

3.2.2.1 Assumptions-based approach

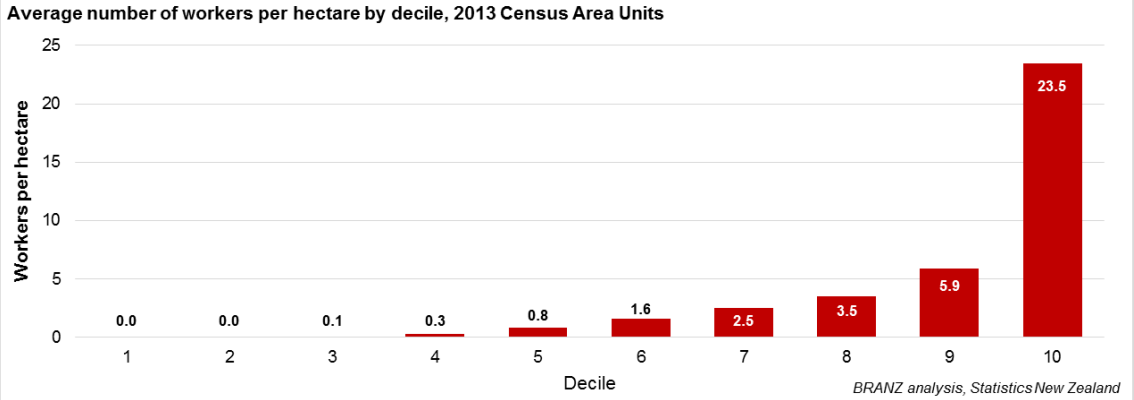
We gathered workplace address data from the 2013 census on the more than 2,000 Census Area Units (CAUs) into which New Zealand is divided.[1] This data shows how many people work in each of the CAUs. For instance, it shows that more than 43,000 worked in the Lambton CAU, which centres on the Terrace and Lambton Quay. On the other hand, just under 600 people work in the Miramar CAU. This gave us a broad idea of which CAUs were the most built-up, in that they have high numbers of workers.

However, this was not the complete picture. Some CAUs may have a large number of workers, but also have a large geographical surface area, meaning they do not need to have many workers accommodated in multi-story buildings. An example of this is Manukau Central CAU, which had more than 11,600 workers in 2013. However, these workers were spread out over more than 1,600 hectares (compared to 99 hectares for the 43,000 workers in Lambton CAU).

We therefore divided the number of workers in each CAU by the surface area of that CAU, to yield an employment density figure for each CAU. When CAUs are arranged from lowest to highest employment density, it is evident that only a small number of New Zealand's CAUs are in high density areas, as highlighted by Figure 8.

[1] CAUs are non-administrative geographic areas smaller in size than Districts or Cities. CAUs must either define, or aggregate to define, regional councils, territorial authorities, and urban areas. CAUs within urban areas normally contain a population of 3,000–5,000 people.

Figure 8 Very few CAUs are built up enough to be dominated by multi-story buildings



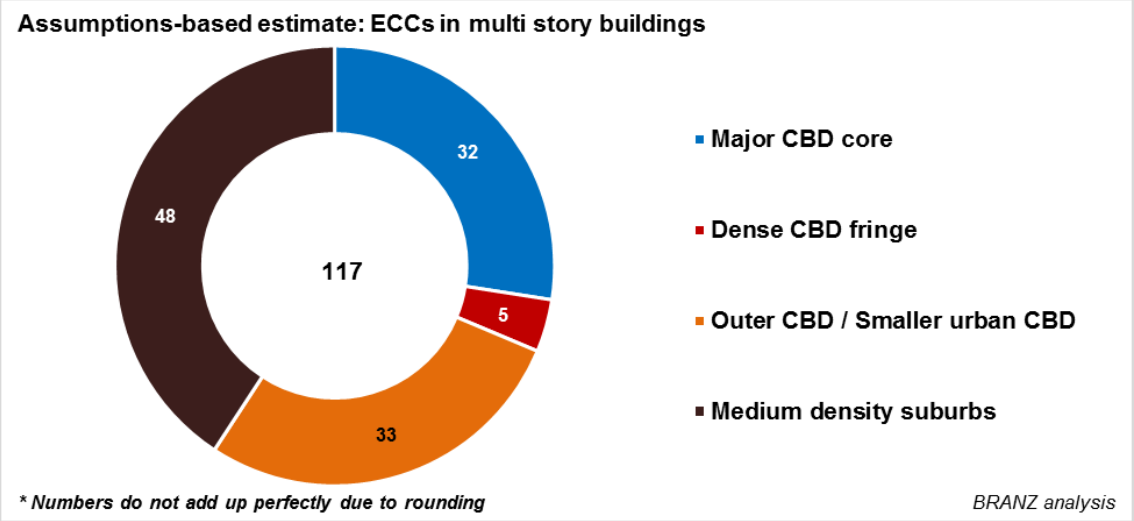
Even the decile with the highest employment density has an average density of just 23.5 workers per hectare. This top decile is skewed by five particularly built-up CAUs in Wellington and Auckland, which together have 118,700 workers at an average density of 263.

Based on this analysis, we adopted an estimation approach that assumed that:

- 100% of ECCs in CAUs with more than 150 workers per hectare would be in multi-story buildings (which we labelled "Major CBD core"). There were five such CAUs with an average density of 263 per hectare.
- 75% of ECCs in CAUs with 100 to 149 workers per hectare would be in multi-story buildings ("Dense CBD fringe"). There were two such CAUs with an average density of 115 per hectare.
- 50% of ECCs in CAUs with 50 to 99 workers per hectare would be in multi-story buildings (Outer CBD / Smaller urban CBD). There were 15 such CAUs with an average density of 62 per hectare.
- 25% of ECCs in CAUs with 23.5 (representing the average density of the top 10% of CAUs as set out in Figure 8) to 49 workers per hectare would be in multi-story buildings (medium density suburbs). There were 31 such CAUs with an average density of 33 per hectare.

There were 293 ECCs in the four employment density categories, according to the MoE database. Of these, 250 were licensed and 43 were playgroups. This yielded an estimate of around **117 ECCs** being in multi-story buildings in these more densely built up CAUs, as shown in Figure 9.

Figure 9 An assumptions-based estimate of all ECCs in multi-story buildings



There are almost certainly some ECCs in multi-story buildings outside of the 53 CAUs included in this analysis. However, given the low density of CAUs not included in this analysis, there are unlikely to be many. At the same time, even some of the dense CAUs included in this estimate will likely have some ECCs that are not in multi-story buildings. These are likely to balance each other out.

3.2.2.2 Survey-based approach

We were still not confident that the assumptions-based approach provided a fair reflection of the proportion of ECCs in multi-story buildings in New Zealand. Further, it failed to answer the question of what proportion of those ECCs were **not on the ground floor** (i.e. requiring children to navigate staircases to exit the building). We therefore decided to undertake a telephone and internet search survey approach to further refine the upper bound estimate developed previously. This research was limited to **licensed** ECCs, and excluded playgroups. Although we did have some data for playgroups, address and contact information for many was confidentialised or missing, as several playgroups in built-up areas function as refuges. This meant it was also not appropriate to call asking for detailed information on location or building type.

Nevertheless, we surveyed:

- 101 ECCs located in “medium density suburbs” (out of 162 in the MoE database)
- 39 ECCs located in “outer CBDs / smaller urban CBDs” (out of 53).

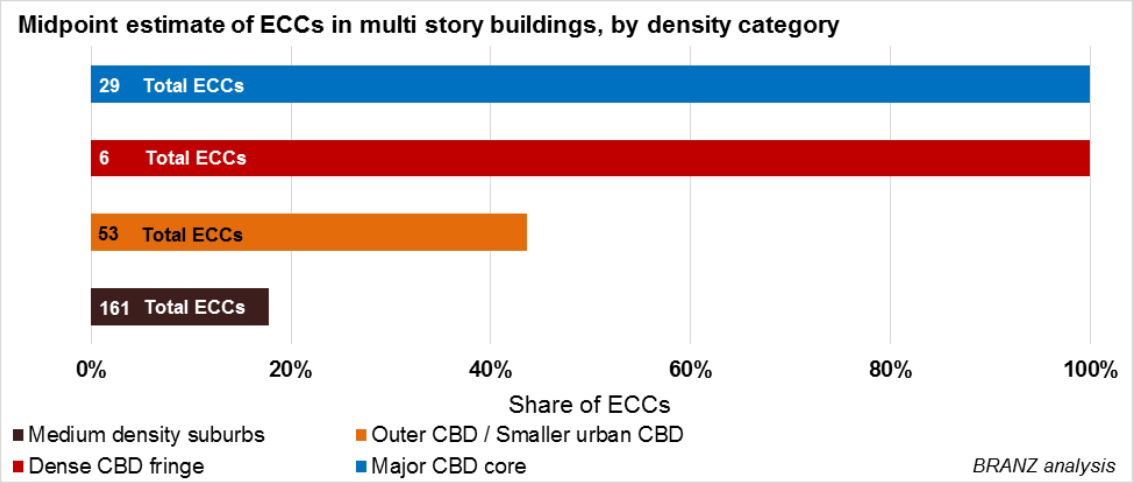
We further researched **all six** ECCs located in “dense CBD fringes” on the internet to identify what type of building they were located in. We also determined whether or not the ECCs were on the ground floor of multi-story buildings.

We found that:

- 100% of the six licensed ECCs in dense CBD fringes were in multi-story buildings.
- Between 36% and 52% of licensed ECCs in outer CBDs / smaller urban CBDs were in multi-story buildings, once margins of error are allowed for.

- Between 13% and 22% of licensed ECCs in medium density suburbs were in multi-story buildings.

Figure 10 The denser the CAU, the higher the share of ECCs in multi-story buildings



This analysis shows clearly that **as employment density falls, the likelihood of an ECC being in a multi-story building falls sharply**, reinforcing the assumption made in our earlier assumptions-based estimate.

By the time we consider dense CBD fringes, 100% of ECCs are in multi-story buildings. This suggested that the vast majority of ECCs in major CBD cores would be in multi-story buildings, as in our earlier assumptions-based approach.

Given the difficulty in determining the building type for playgroups, we assumed that these would be as likely to be in multi-story buildings as licensed ECCs in each employment density category. If anything, this **may over-estimate the number of playgroups in multi-story buildings**, for at least two reasons:

- In the limited information we had on playgroups, it was obvious that many were in churches and school halls. These are likely to be located on the ground floor or in single storey buildings.
- The ratio of playgroups to licensed ECCs was lower in the 53 higher density CAUs than in the rest of the country. This suggested that playgroups tend to be more common outside of built-up areas, which indicates that as an ECC type they may be more likely to be in single storey buildings.

In summary, the survey and internet research suggested that **between 86 and 114 ECCs in New Zealand are in multi-story buildings**, or around 1.7% to 2.3% of ECCs. This includes between 11 and 16 playgroups, and 75 to 98 licensed ECCs.

Between 86 and 114 ECCs in New Zealand's densest CAUs are in multi story buildings, but this does not tell us how many would require children to navigate stairs to evacuate the building.

However, the NZFS is primarily interested in the number of ECCs located **above ground floor** (i.e. potentially requiring children to navigate stairs to exit in the event of an emergency). In our telephone and internet survey, we also checked whether ECCs located in multi-story buildings were located on the ground floor. In the case of ECCs in multi-story purpose-built or residential buildings,

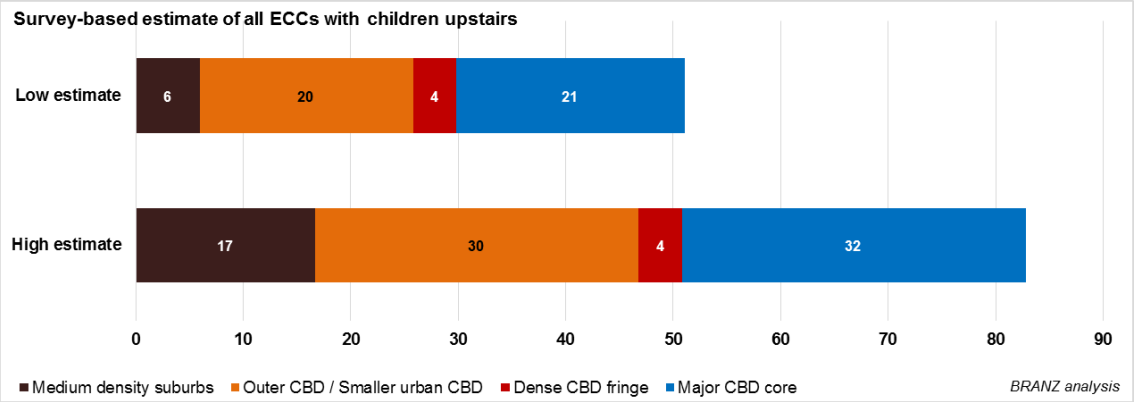
we checked whether the upstairs floors were used for children or only administrative tasks.

We found that:

- Two-thirds of the six licensed ECCs in dense CBD fringes had children upstairs.
- Between 31% and 46% of licensed ECCs in outer CBDs / smaller urban CBDs had children upstairs, once margins of error are allowed for.
- Between 3% and 9% of licensed ECCs in medium density suburbs had children upstairs.

Once again, this allowed us to estimate the total number of ECCs that are likely located in multi-story buildings where children would need to navigate stairs in the event of an evacuation. These results are set out in Figure 11.

Figure 11 Between 51 and 83 ECCs may require children to navigate stairs



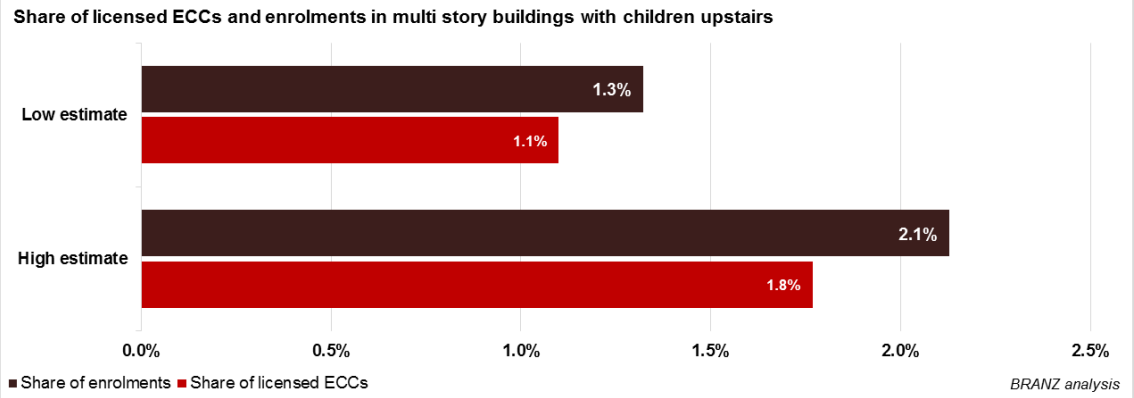
Between 51 and 83 multi-story ECCs are estimated to have children upstairs. These figures include between 45 and 72 licensed ECCs (1.1% to 1.8% of all licensed ECCs in the MoE database), and six to 11 playgroups (0.6% to 1.2% of playgroups).

The bulk of these ECCs are likely to be in the two least dense groups of CAUs in our study. This is because of the number of ECCs there, rather than because of a predominance of multi-story ECCs.

As already highlighted, the proportion of ECCs in multi-story buildings falls sharply as employment density falls. Further, there are not the space constraints (with commensurate land costs) outside of the 53 high-density CAUs examined in the survey. We conclude that it are likely to be few ECCs in multi-story buildings where children would need to navigate stairs in an emergency outside of the higher-density CAUs. The upper bound estimate of 83 ECCs (covering licensed ECCs and playgroups) is likely to be a fair estimate for New Zealand overall. This suggests **around 1.8% of ECCs are likely to be in multi-story buildings where children are upstairs**.

Another way to look at this is to consider the share of enrolled children affected. Enrolment data is not available for playgroups, but we can estimate the number of enrolled children in **licensed** ECCs who are likely to be upstairs.

Figure 12 ECCs in higher-density areas are slightly larger



On average, licensed ECCs in the 53 higher-density average a little over 50 children per ECC. When these are weighted by their likelihood of being in multi-story buildings with children upstairs, the average rises to 55. Across the 45 to 72 licensed ECCs estimated to have children upstairs in multi-story buildings, this yields 2,450 to 3,940 children. This equates to 1.3% to 2.1% of all children based on enrolment data from the MoE, compared with 1.1% to 1.8% of licensed ECCs. In other words, a slightly higher proportion of enrolments than ECCs are in multi-story buildings with children upstairs.

3.3 Changes in the number of ECCs in multi-story buildings

We would also like to understand what the trends have been in the number of ECCs in multi-story buildings that would require children to navigate stairs in the event of an emergency. MoE data for the number of ECCs in 2006 (both licensed and playgroups) was requested as this data lined up best with the 2006 census data.

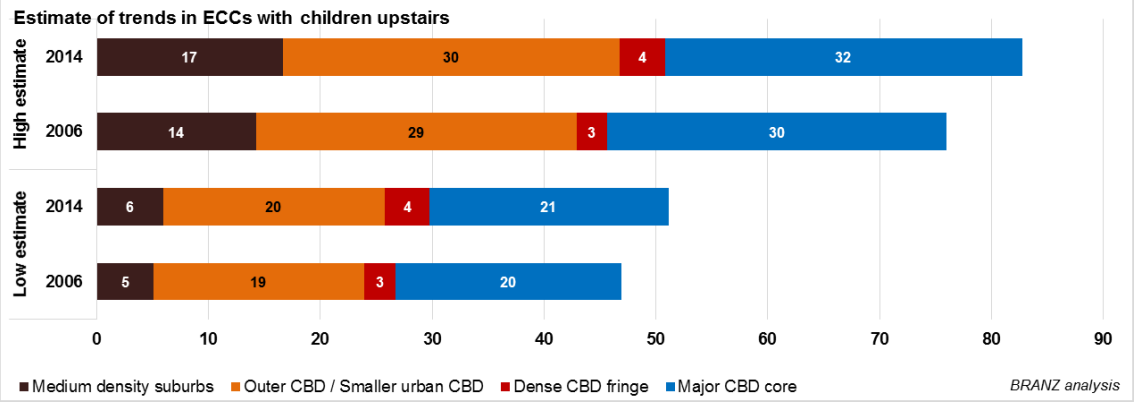
Unfortunately, the older data is not as comprehensive or reliable as 2013 and 2014 data. For instance, nearly two hundred playgroups (around 4.3% of the total in the database) do not have CAUs associated with them. This makes it more challenging to compare results from the 53 higher density CAUs from 2013/14 with those from 2006. Secondly, several ECCs appear to have been assigned to the incorrect CAU, and there are multiple examples of double-counting in the database.

We made every reasonable effort to remove double-counting and to correct CAU assignments for the higher-density CAUs where possible using the SNZ StatsMaps tool.

Nevertheless, the problem of 4.3% of ECCs not being coded to a CAU meant the data was incomplete. We therefore assumed that the ECCs for which no matching CAU is available are uniformly distributed across CAUs. As a result, we simply divided the number of ECCs recorded in 2006 across the 53 higher-density CAUs by (1 minus 4.3%). This yielded the estimate of the total number of ECCs in those 53 CAUs in 2006.

The result was an estimate of 259 ECCs in the 53 CAUs in 2006, suggesting an increase of 34 between 2006 and 2014. Of these 259 ECCs in 2006, an estimated 47 to 76 were in multi-story buildings where children would be upstairs. The estimates are shown and compared to 2014 estimates in Figure 13.

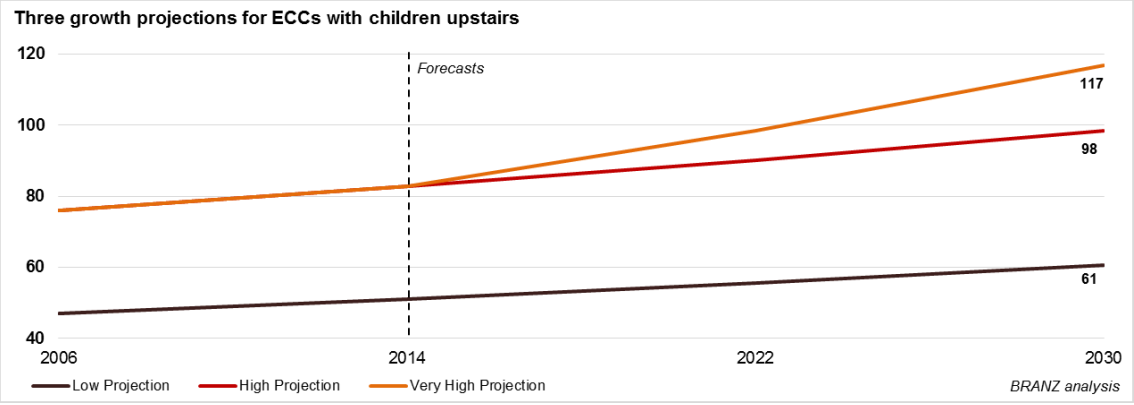
Figure 13 Changes in the number of ECCs with children upstairs appear to be limited



We would recommend some caution when interpreting these results. The data seems to indicate that growth in the number of ECCs with children upstairs has been relatively slow. However, the quality of the 2006 data means growth may have been greater or less than the 1.1% per annum growth suggested by Figure 12.

Using the growth rates and estimated number of ECCs with children upstairs set out in Figure 11 and Figure 12, we were able to project growth out to 2030. This is shown in Figure 14.

Figure 14 Growth projections could see ECCs with children upstairs reach 117 by 2030



We also developed a "Very High" projection, where we doubled growth rates over the last eight years. We assumed the higher starting point for the number of ECCs with children upstairs for 2014. This yielded **117 ECCs in multi storey buildings with children upstairs by 2030**, or 2.3% of today's population of ECCs. Presumably, the share of ECCs in multi-story buildings with children upstairs in 2030 would be a smaller percentage of the total ECCs at that time – probably in the region of 2%. This is because the number of ECCs in single story buildings would also grow over this time.

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4. CURRENT NEW ZEALAND REQUIREMENTS FOR ECCS

The current building design requirements for ECCs are set in the New Zealand Building Code clause C. An acceptable solution is provided in C/AS4 Acceptable Solution for Buildings with Public Access and Educational Facilities. There have been a series of amendments to the Acceptable Solution since 2012. In April 2012 buildings with ECC on an upper level were required to have sprinklers installed. In December 2013 the requirement for two places of safety at each floor occupied by ECC with direct access to safe paths was added. The required fire resistance rating (FRR) is 30 minutes minimum with sprinklers, smoke detectors, and alarms.

As well as the Acceptable Solution, the New Zealand code allows for an alternative means of compliance, namely C/VM2 Verification Method: Framework for Fire Safety Design. This uses a rational design methodology for designing passive and active fire protection measures. This includes the calculation of the required and available escape times.

For new ECCs the changes provide enhanced safety. The occupants can evacuate as normal, or either wait for the fire to burn-out or to await assistance in evacuation from the places of safety. They may also wait there until other building occupants have evacuated and then proceed with their evacuation. The NZFS may be able to assist in evacuation but they provide no guarantees that they will do so as there will be other demands on their people.

The Fire Safety and Evacuation of Buildings Regulations 2006 has a number of relevant requirements.

There is more general legislation related to fire safety in the occupancy of buildings. The *Fire Safety and Evacuation of Buildings Regulations 2006* has a number of requirements relevant to ECCs including:

- The owner is to maintain means of escape.
- Evacuation schemes for new and existing buildings require approval and the application forms (with extensive data requirements) are in the Schedules of the regulation.
- An *Evacuation Scheme Approval* and an exemplar is provided for ECCs on the NZFS website.
- The owner is to erect signs and notices indicating the evacuation procedure.
- Employees of the owner and tenants are to be trained to assist occupants to evacuate.
- Trial evacuations are to be carried out for multi-storey buildings at not less than 6 month intervals. The results of the evacuation (including time for evacuation) is to be reported to the NZFS.
- The NZFS may require a trial evacuation at 2 days' notice if the National Commander believes the evacuation scheme no longer complies with the regulations.
- The tenants are to provide the names and positions of the person(s) required to remain with occupants in Places of Safety.

The training requirement for those assisting others in evacuation is worded:

- ”occupants of the building who are employees of the tenant must be trained to assist any other occupants of the building to evacuate the building, in a fire emergency requiring evacuation, in accordance with the evacuation procedure for the building”.

This suggests other occupants of the building could assist in the evacuation of the ECC. However, this is only likely to apply if other occupants had practiced evacuation of the children and they were part of the evacuation plan. It appears to allow other tenancies to assist the ECC in evacuation, assuming they were part of the plan.

The Education (Early Childhood Services) Regulations 2008 set a variety of criteria including child to staff ratios. These ratios vary according to the mix of child ages, and are a maximum of 5:1 for under- twos and 10:1 for over-twos. There are limits on total numbers of children, and there are minimum floor space requirements per child. The only reference to fire safety is in clause 46 1d. This clause requires every licensed childcare service provider to “take all reasonable steps to ensure that appropriate procedures are in place to deal with fires, earthquakes, and other emergencies.”

The Education (Early Childhood Services) Regulations 2008 set child to staff ratios ranging from 5:1 for under- twos to 10:1 for over-twos.

As mentioned above, the NZFS requires evacuation plans for most non-residential buildings plus 6 monthly trial evacuations. The Ministry of Education (MoE) has issued an operational guidance document entitled *Evacuating children from Early Childhood Education centres in high-rise buildings.* It states that owners cannot rely on a NZFS approved fire evacuation scheme for the building as evidence that it complies with the Ministry’s requirement for evacuation. The particular concerns of the Ministry include:

- Child behaviour in case of fire.
- How to evacuate non-walking children.
- Effectiveness of staff training, with potential for evacuation plan failure.
- Risk associated with other occupants of buildings, including creating hazards in stairways, and shared stairway evacuation.
- Places of safety outside, often near busy streets or in car parks.

The preference in the guidance document is that ECCs within multi-story buildings are located on the ground floor. When this is not possible the MoE expect an evacuation procedure that will directly mitigate the risk. In particular the procedure is to allow for appropriate adult-child ratios dependent on the age mix of the children. The fire safety plan is to consider risks arising from other building occupants or relieving staff unfamiliar with the procedures. It is to be simple so it is robust in the event of unexpected behaviour or events.

The operational guidance document is comprehensive and covers the following:

- Identification of children’s needs (i.e. carried, assisted walker, non-assisted walker).
- Preparation (initial assembly, staff responsibilities, carrying equipment).
- Communication (with building supervisor, within the ECE centre).

- Evacuation (carry, walk, bucket chain).
- Adults roles (varied ratios for different age groups).
- Equipment checks are carried out regularly.
- Staff (training and roles, including relievers, back-ups for absences).
- Evacuation drills (records, review).

It recommends trial evacuations be done monthly for ECC services above ground level in high-rise buildings. Drill records should be kept of time for egress, the ages of children, and any issues that arise.

Guidance recommends trial evacuations be done monthly for ECCs above ground level in high-rise buildings.

The MoE can withhold licensing for ECCs in multi-story buildings if they are not persuaded that the safety measures are adequate. The guidance document is the main yard-stick for this. It is a matter of judgement by MoE on whether an individual ECC conforms to the document. This allows for flexibility but it is not certain that consistent criteria are used for each ECC.

The licensing criteria for ECC are set out in a MoE document *Licensing criteria for early childhood education and care centres 2008.* It covers curriculum, facilities, health and safety, and governance. Health and safety criteria HS4 states "The premises shall have a current Fire Evacuation Scheme approved by the NZ Fire Service." This covers evacuation of all tenants from the whole building and does not have requirements specific to an ECC environment. The ECC cannot rely on this approval as satisfying all requirements because there are other MoE requirements set out in HS7. The latter covers having a detailed plan and process for evacuation (including fire, flood, earthquake, tsunami, etc). The service provider needs to develop these plans and processes and the MoE is responsible for approving these to the requirements of HS7. It is suggested later that the NZFS also be involved in this fire evacuation planning process.

A final piece of legislation covering fire in buildings is the *Civil Defence Emergency Management Act 2002*. The only reference to occupants in multi-story buildings is that the Controller can order evacuation of any premise for preservation of life. The Controller has power to give direction including to "request any person….to take any action to prevent or limit the extent of the emergency." This probably means the Controller could direct persons to assist in the evacuation of buildings. However it is unlikely to happen because in a fire emergency the NZFS personnel are the appropriate rescue service. Other people immediately available are unlikely to have the skills to assist, except possibly other emergency services such as police and first aid services. The relevance of this legislation to ECC fire safety is minimal.

5. LITERATURE REVIEW

This review examines three types of documents:

- The building code requirements in a selection of countries.
- Research papers related to the behaviour of staff and children in the case of fire evacuation drills.
- Guidance and performance documents explaining local regulations and/or non-mandatory practices that improve safety.

5.1 Building codes and regulations

The requirements for childcare centres in New Zealand are achieved by either using the Acceptable Solution C/AS4 or showing compliance by the Verification Method C/VM2. The documents are C/AS4 Acceptable Solutions for Buildings with Public Access and Educational Facilities (Risk Group CA). The verification method document is C/VM2 Verification Method: Framework for Fire Safety Design.

C/AS4 was amended recently, taking effect from 1 July 2014. The main changes were to include childcare centres in Risk Group CA with occupant density based on *Education (Early Childhood Services) Regulation 2008*. Special requirements includes Type 7 alarms (i.e. smoke detectors, a fire sprinkler system, and alarms connected to the nearest fire station) for ECCs above ground level. Also, above-ground level centres require two separate "places of safety" per floor, each with direct access to a "safe path" for escape. The features in quotes have specific fire safety performance criteria.

The Verification Method (VM) in New Zealand allows for a calculation for an available safe egress time (ASET) which must be larger than the required safe egress time (RSET). There is no required margin between the two, only that ASET is larger than RSET. This suggests a minimal safety margin.

The required safe egress time (RSET) is quite conservative (i.e. it errs on the side of caution).

However the calculation of the ASET and the RSET are quite conservative (i.e. they err on the side of caution). For the latter it includes the sum of time to detect, notify, prepare to move, and travel/ queuing times. All these separate times appear to be conservatively calculated. For example, for adults the stair speed in the VM is about 0.65 m/sec but tests show speeds closer to 1.0 m/sec. Also the other times in the VM, while less significant than travel speed, are quite generous. The VM does not provide guidance of travel speed for children, so designers should be very conservative for ECCs. This is discussed later.

Table 1 is a summary of the findings for 12 jurisdictions abroad, plus New Zealand. The New Zealand data in the table below is from the acceptable solution approach.

Table 1 ECC fire safety regulations in selected countries

Childcare centres building regulations > 1 storey		NZ	USA	UK	Singapore	Finland	W Australia	NSW	Sweden	Ireland	Norway	Belgium	Denmark
FRR between occupancies (1)		30min	60-180 min	30-60min	0-60min	60min	120 min	120 min	60min	30min	30-60min	60 min	120 min
FRR for escape routes		60min	nil	30min	60min	60min	120min	120min	60min	30min	30-60min	60 min	120 min
Child:staff ratios (2)	<2yrs	5:1	4:1	4:1	5:1	4:1	4:1	4:1	?	5:1	?	8:1	?
	>2yrs	10:1	9:1	8:1	?	7:1	10:1	10:1	?	10:1	?	8:1	?
Number of escape routes		2	1	1, <60 persons	1, <50 persons	2	1	2	1	2	2	1	2
Horizontal travel distance to exit (3)		unlimited	60m	18m 1 escape, 45m 2 escape	15m 1 escape, 30m 2 escape	45m	20m	40m	30m	20m <2 yrs, 45m >2 yrs	50m	30m	25m
Sprinklers required		yes	yes	no	no	no	yes	yes	no	no	no	no	yes
# Places of safety		2	nil	nil	nil	nil	nil	1	nil	nil	nil	nil	nil
Fire drills		six monthly	quarterly	yearly	nil	six monthly	yearly	six monthly	nil	monthly	yearly	yearly	nil
(1) Depends on occupancies and whether sprinklered.													
(2) Not a building regulation, instead usually an education, or health authority requirement. Age group boundaries not always at 2 years, see Appendix.													
(3) May vary if sprinklers installed, see Appendix.													

Note: The USA has several fire codes and the one used was their International Building Code.

Table 1 indicates that there are some variations in the requirements between countries for the various safety measures. For example, the FRR for the stairway escape routes is between nil minutes and 120 minutes. The maximum horizontal travel distances to the escape stairways varies considerably. Often for a single country a low requirement in one measure is off-set by a high requirement in another measure. For example, in New Zealand the unlimited allowable horizontal travel distance is compensated by a requirement for sprinklers, 2 escape paths and places of safety, which most countries do not have.

Some of the items in the figure are from sources other than building regulations. For example, child to staff ratios, which could have an effect on evacuation times, vary between 4:1 and 10:1 and are usually mandated by the education authorities in each country.

A summary of European child to staff ratios is provided in *More Great Childcare: raising quality and giving parents more choice* (Department of Education UK, 2013). The paper outlines proposals to raise the qualification requirements and slightly reduce current child to staff ratios. The report finds UK childcare staff salaries are significantly below the six other European countries in the report and the aim is to raise the overall quality of staff in the sector. It suggests this quality improvement will offset the higher than average ratio of children to staff.

Approved child to staff ratios, which could have an effect on evacuation times, vary between 4:1 and 10:1.

In Australia, the different states have similar though not identical requirements for ECCs in multi-story buildings. The *Queensland Childcare Act 2002* places onus on the chief executive of the centre to ensure it is safe for use as a child care centre. The matters to be considered include whether the centre is above ground level. A risk assessment report may be requested for these centres before they are licenced.

In Victoria, the Metropolitan Fire Service provides guidelines for childcare centres. Chief among the requirements is a strong recommendation the centre be on the ground floor. If that is not possible, then it should be on the first level above ground. If that is not viable then the centre should never be located at greater than 25 metres height, i.e. about 6 stories. This height limit is so the fire service can facilitate rapid access via aerial appliances. The requirements for a centre above ground level include:

- A safe refuge with direct access to fire isolated stairs.
- Direct service by a dedicated lift.
- A minimum FRR of 60/60/60 minutes (the numbers refer to the fire separation resistance under structural loading, containing hot gases, and transmission of heat respectively).
- Pressurised refuge and the stairs.
- An intercom in the refuge area.
- Sprinklers throughout the building.

5.2 Childcare centre safety research

A major part of the research into childcare centres involves evacuation of children in the event of fire. This includes studies of actual evacuations, including time to escape, and child and staff behaviour during evacuation. Early research in New Zealand considered the fire safety knowledge of vulnerable groups and a NZFS report on this is considered first.

Improving the fire safety knowledge and practices of vulnerable groups

Produced by the New Zealand Council for Educational Research (2000) for the NZFS (Report No. 8, 2000).

The three vulnerable groups considered in the report were children under five, people aged over 65 years, and low income households. The report covered under-fives at home as well as in care. It was mainly about child behaviour and whether they can learn safe practices. Learning is very age-specific and pre-schoolers remember images (e.g. of a lighter) but not the accompanying safety message. They will learn behaviours if they are practised, e.g. evacuation practices, which need to be frequent. They will understand the reasons for evacuation if explained simply, and practising evacuation helps reduce fear.

Learning is very age-specific and pre-schoolers remember images (e.g. of a lighter) but not the accompanying safety message.

However, retention of learning is often incomplete especially in the very young. The recommended emphasis for childcare safety is more on the caregivers than the children. The three key messages for caregivers are:

- Continually supervise children.
- Understand the risks to children of fire.
- Remove environment hazards, especially matches and lighters.

Determining self-preservation capability in pre-school children: Technical notes

Written by Taciuc and Dederichs for the Fire Protection Research Foundation, Denmark (2013).

This survey-based work was to understand young child behaviour in fire evacuations, with varied child-adult ratios, alarm systems, staff training and frequency of fire drills. The conclusions were based on surveys with 87 responses (62 teachers and 25 fire experts) from five countries (USA, Germany, Denmark, Romania, and Canada). The findings included:

- Between 30 and 36 months, children are generally capable of understanding and following simple fire evacuation instructions.
- Between 24 and 30 months, they can generally walk down stairs.
- Younger than 24 months, they can evacuate horizontally without assistance (unless they are toddlers or babies).
- Teachers say between 24 and 30 months children will not become upset by unusual events (e.g. fire and emergency evacuation).

- The number of fire drills varies enormously between countries (e.g. USA nine per year median, Denmark and Germany zero or one per year).
- The child-adult ratio varies significantly. For children under two, the median is four in the USA and Denmark, and six in Germany. For children between 24 and 30 months, the median ratios are four in the USA and Denmark, and eight in Germany. For children older than 30 months, the median is ten in the USA and Germany, and five in Denmark.
- Almost 50% of teachers said they could carry one or two children in an evacuation. The rest would hold a children's hands to assist evacuation.

Evacuation of children: Movement on stairs and on horizontal plane

Written by Larusdottir and Dederichs for the Department of Civil Engineering, Technical University of Denmark (2010).

Travel speeds were measured for 1,078 child trips, about 330 of which were the same children measured twice. Horizontal and stair travel speeds were recorded. Three different sets of stairs were used, all of which were spiral. The number of stories travelled was not mentioned, but indications from the report are that is was no more than three levels.

The horizontal travel speed for those under two was 0.6 m/sec, and for those aged three to six, 0.84 m/sec. On the spiral stairs only the three to six year olds were measured. For stair 1, at a 33 degree slope, with a good handrail, a stair used by the children every day, the average speed was 0.58 m/sec. Stair 2, at a slope of 33 degrees, rarely used, with an inconvenient handrail, the average speed was 0.38 m/sec. Stair 3 is exterior, with a see-through mesh floor, at a slope of 30 degrees, never used by children before, with a high and hard to grip handrail. It had an average speed of 0.13 m/sec. All travel was single file since the stair widths (between 0.80m and 0.91 m) were insufficient for two abreast.

"It is common that models, which are designed for data on adults, are scaled to fit children without further investigation."

The authors comment:

> *"Nowadays evacuation models badly comprehend the behaviour of children. This suggests that children are less safe in buildings than adults. It is common that models, which are designed for data on adults, are scaled to fit children without further investigation. More data is needed for further understanding on the subject."*

Empirical data analysis and modelling of the evacuation of children from three multi-story day-care centres

Written by Campanella et al for the Technical University of Denmark (2011).

Three semi-unannounced evacuation drills were performed in downtown Copenhagen involving 127 children between 0 and 6 years, plus staff. The buildings were three stories with children on all levels. The alarm was verbal by the person in charge rather than a fire alarm. There was some delay (up to one minute) as the responsible person moved

from room to room to notify the children of the evacuation. As a result, the evacuation time was found to be slightly longer than predicted using the Nomad tool, (a pedestrian simulation model).

The evacuation proceeded smoothly. Children were stopped by some doors which they found difficult to open. Older children rushed out but younger children were more confused. The maximum evacuation time was just over six minutes for one building and two minutes for the other two buildings. Some of the delay was caused by the slow reaction of other staff. The travel speeds down stairs for the three to six year olds varied for the three centres between 0.1 m/sec and 0.6 m/sec.

Study of children evacuation from pre-school education institutions

Written by Kholshchevnikov et al for Fire and Materials 2012 36:349-366.

This is the most comprehensive study found on evacuation times for children able to walk, covering horizontal, up and downstairs, and through doorways. Eight kindergartens in Moscow were used in the research, and several evacuations were done in each kindergarten. It appears that supervisor training and practice drills were at best infrequent before the study started. Average speeds down stairs was about 0.3 m/sec for children up to three years. For four to five year olds it was about 0.5 m/sec. Older groups five to seven years averaged about 0.9 m/sec. These rates were for three children/m^2 on stairs and the recorded speed slowed as the children/m^2 increased. The pre-movement time after the alarm varied between summer and winter. In summer it averaged about 30 seconds but in winter it was about four minutes as children needed to find and don their outdoor clothing.

Evacuation speeds are highly dependent on season and practice.

Evacuation timing computations using different evacuation models.

Masters thesis in fire engineering, written by Tan, University of Canterbury (2011).

Various evacuation models were examined. These give travel speeds of roughly 1 m/sec for adults on the flat and 0.5 m/sec on stairs. For children (about two years old) the speed is about half this. The project looked at evacuation times for four building types, using three software models plus the hand calculation method recommended in the NZ Building code C/VM2. One of the buildings is a four-story office building and the four methods estimated evacuation times within 10% of each other. The maximum was less than four minutes for complete evacuation. However, adult occupants were assumed in these case studies. The pre-movement time for adults varied between 30 seconds and 60 seconds.

Report of the preschool fire safety messaging meeting

Written by the National Fire Protection Association, 2008, NFPA Headquarters Quincy, MA 02169.

The NFPA hosted education and childcare groups to ascertain what fire safety messages were being taught, mainly to the under-fives. The meeting found that local fire

departments usually do the teaching. The main concepts in locally developed programmes, applicable for at home or in childcare centres included:

- Calling 911.
- Escape routes.
- Smoke alarms.
- Crawling low under smoke.
- Stop/ drop/ roll.

The meeting decided these were not all appropriate for teaching to young children. Instead it was decided the main messages to get across to children are:

- Fire fighters are friends.
- Stay away from hot things.
- Matches and lighters: tell a grown up, never touch.
- Familiarise children to the sound of the smoke alarm.
- Practice a fire escape plan (at home or in the childcare centre).

The report has several case studies of how to deliver the message to children. It reports on studies of before and after teaching and which methods significantly improve child responses to practice fire events.

Fire safety regulations for housing in Europe compared.

Written by Visscher et al for Building Research Journal Vol 56, 2008.

This paper is mainly about fire safety in housing for eight European countries and includes discussion on apartments and non-residential tall buildings. In the housing sector, there is considerable similarity in the four main aims that are common to all eight countries. These are:

- Maintenance of structural stability.
- Limitations on fire spread.
- Appropriate escape routes.
- Limitations on the initiation and development of fire.

However, there are notable differences in the requirement details. For example, FRR requirements vary widely, particularly for flats and apartments. Further, in taller buildings the maximum travel distances (horizontal travel to the protected stairway) varies between 20m and 60m in medium rise flats. The building details for smoke detectors and alarms also varied significantly. There was no discussion of any extra features required for child care centres.

FRR requirements vary widely across countries, particularly for flats and apartments.

Means of escape in multi-story buildings

Written by C Wade for BRANZ Study Report 38 (1991).

An early report into the engineering basis of fire safety design reached a number of conclusions which were later adopted into the NZBC Acceptable Solutions. These included:

- A holistic approach to design.
- Two means of escape for multi-story buildings with adequate separation.
- The need to specify maximum travel distances.
- The use of modelling for escape times.
- A caution that unexpected human behaviour should be considered in setting design parameters.

There was no particular consideration of child evacuation.

Emerging egress – merging flows at floor stairway interfaces

Written by P Collier for BRANZ Study Report No. 251 (2011).

The evacuation interface between floor exits and the stairway was studied. The study found that, theoretically, the junction does not affect the total evacuation time assuming that the merging at each floor occurs within quite wide ratios. The ratios used were between one person per floor for every 10 in the stairway, and 10 persons per floor per one in the stairway. The report notes problems could arise with panic behaviour in which people could be injured on stairways. Obviously children could be most at risk in such situations.

Accessible emergency egress – literature review and scoping study

Written by Robbins and Buckett for BRANZ Study Report 318 (2014).

A broad literature view on building egress in general was undertaken. There was no data on children on stairs. The authors noted that studies of similar occupancies and emergencies had a quite large range of results of evacuation speed for adults. They appear to be recommending the combination of data from various sources to get likely ranges in egress speeds. The designers should then use their judgement as to where in the range the design travel speed is selected.

The effect of safety factors on timed human egress simulation,

A Master theses at the University of Canterbury, (Crawford 1999).

This thesis has interesting survey data from NZ building designers. The sample is small, only 8 responses. Assumed travels times (for adults) used in their designs was between 1.0-1.3 m/secec. Reaction times assumed (before evacuation) varied widely, between 30 seconds and 6 minutes depending on the building type. The factor of safety (FS) used for evacuation times till untenable conditions prevailed was commonly 2.0 (i.e. occupants need to be out in 50% of the time calculated to failure). However one designer used a SF of 3. The report recommended a minimum FS of 2.0.

Factors of safety between 2.0 and 3.0 are typically used.

The thesis notes that evacuation times used in design are based on tests, and the mean values from these tests are often used in design. There is a range of times in these evacuation tests which generally following a bell curve. A similar bell shape is seen in

fire resistant tests, with most tests near the mean but some higher or lower. In a performance-oriented design the aim is to ensure the difference between the 2 means (or factor safety) is sufficient to ensure that the 2 curves do not touch. If bell shapes are quite flat (i.e. a wide range of values from tests) then they may touch, in which case the aim is to ensure the area of overlap (i.e. failure) is very small. This is achieved by using a high factor of safety.

Summary of childcare centre safety research

The main conclusions from these research papers is that a rational basis for fire design is generally used, based on testing and measurement of actual behaviours such as egress time. The research shows actual times for child evacuation are significantly more than for adult-only occupancies and travel down stairs varies between 0.1 m/sec and 0.9 m/sec depending on the age of children. The slower speeds are for very young children not comfortable stepping down stairs, and requiring assistance from adults for much of the descent. There was no data on speeds of adults carrying children, but these are likely to be around that of the older walking children (i.e. 4-5 years). Pre-movement times are also slower for children than adults as supervisors need to organise the children and calm any fears they may have.

Research shows actual times for child evacuation are significantly more than for adult-only occupancies and travel down stairs varies between 0.1 m/sec and 0.9 m/sec depending on the age of

It is uncertain what factor of safety is built into the Acceptable Solution. It is difficult to calculate in any case since a mix of measures is required (FRR of components, sprinklers, two escape routes, and places of safety). Clause 2.5 in C/VM2 indicates the factor of safety is 3 for the verification method. However the survey for the Masters theses above (Crawford 1999) indicated a factor of safety of 2 was used at that time by designers. Given the sensitivity around care of children a higher factor of safety of 3.0 should be used for evacuation design as per VM2. This factor is used later in the evacuation analysis section.

5.3 Guidance documents

Guidance documents explain regulations in simplified language and often suggest extra measures although these are not mandatory.

Fire safety risk assessment: Residential care buildings

Written by HM Government, United Kingdom, 2006.

This comprehensive guide applies to England and Wales only. It does not set prescriptive standards, but provides recommendations and guidance for use when assessing the adequacy of fire precautions in premises providing residential care. The guide also provides recommendations for the fire safety management of the premises. Among these is a periodic Risk Assessment, which should include:

1: Identify people at risk

2: Identify fire hazards

- Sources of ignition
- Sources of fuel
- Sources of oxygen

3: Evaluate the risk and decide if existing fire safety measures are adequate

- Evaluate the likelihood of a fire starting
- Evaluate the consequence to people from fire

- Implement fire safety measures
- Remove or reduce fire hazards
- Remove or reduce risks to people
- Install fire alarm as needed
- Install Fire-fighting equipment as needed
- Ensure escape routes and lighting are adequate and clear
- Signs and notices
- Maintenance
- Effective management
- Staff training

4: Record significant findings and action taken / action to be taken

5: Review - Keep assessment under review and revise where necessary.

Practical fire safety guidance for educational and day care for children premises

Written by Safer Scotland, Scottish Government, 2008.

This guide is very similar to ones used for Residential care buildings mentioned above. It includes periodic risk assessment for employers in childcare centres, and when alterations and additions are made to these centres. Buildings with more than three stories require two escape routes, with distances of less than 32 m.

Fire safety in pre-schools

Written by Ireland Government, 1999.

The Guide sets out general principles of safety which should be applied having regard to the individual circumstances of different premises. The recommendations in this Guide are advisory only and are not statutory requirements. However, the provisions of the Guide, if carefully applied, should minimise the occurrence of fires in these premises and the potential for fatalities, injuries and damage

The guidance sets FRRs of 30 minutes and escape distances of 20 metres for under-twos.

The guide has little on multi-story buildings above two stories. With two-story buildings the escape distances are 45m for active children (presumably older than two years) and 20m for sleeping children (under 2 years). The escape routes are to have FRR of 30 minutes. Alarms and smoke detectors are required in all fire cells.

Life Safety Code

Written by the National Fire Protection Association (NFPA), 2012.

This code has been adopted by many states in the USA. For child care centres above ground level the requirements include:

- Sprinklers in the whole building.
- For mixed occupancies 1 hour fire barriers.
- Two exit paths for each floor.
- Corridors to have self-closing smoke barrier doors.

- Travel distance cannot exceed 150 feet.
- Vertical opening (i.e. stairways, shafts, etc.) to be enclosed with a 1 hour rating for 3 stories or less, and a 2 hour rating for more than 3 stories.
- Fire alarm connected to the local fire department.
- Smoke alarms in most rooms (sleeping, recreation, lounges, and corridors).
- Emergency egress and re-location drills to be executed once a month (except in cold months).
- Fire protection inspections conducted monthly by a trained staff member. The inspection form is to be posted in the day care centre.

Fire Drills Report

Written by the Office of the Fire Marshall, Ontario, Canada, OFM-TG-01-2004.

This guide is based on the Ontario Fire Code. For day-care centres fire drills shall be held monthly. Accidental activations are considered to be a fire drill and require a thorough documentation because they provide a real life assessment of the actual response of staff and children. Fire drill/ incidence report templates are provided and are to be filled out and kept for at least 12 months.

Literature summary

Building regulation and codes are mainly concerned with the initial construction of a building and the provision of adequate safety measures. The NZFS does some inspections of existing buildings but these are not mandatory nor regular. Hazards can arise between these semi-official inspections, such as blocked egress routes and damaged safety features.

The guidance documents have useful information on more frequent safety checks, to be initiated by the owner. In particular, they provide guidance on whether egress routes are clear, signs and notices are visible, safety and evacuation equipment available, and all staff are adequately prepared.

The data on child safety research is mainly on the ability of young children to absorb safety messages and their behaviour during evacuation. It has some useful data on travels speeds down stairs, based on actual evacuations, though from only two or three stories.

5.4 Applying codes, research and guidance to New Zealand

Having considered New Zealand and international guidance and best practice, it is important to consider how overseas requirements compare with those in New Zealand.

Building codes and regulations

In general the current safety provisions in New Zealand are similar to those in other countries. The main differences are:

- Internationally, the required FRR in the stairway of buildings above three levels is often higher than in New Zealand.

- However, the local requirement for 2 escape route, 2 places of safety, and provision of sprinklers is equal to or higher than most other countries in the survey.

The required number of fire drills varies. The USA supposedly has monthly drills but it is uncertain how rigorously this is enforced. The three month recommendation in NZ is lower-range. The turnover rate of staff in Childcare Services is about 18%pa. This is not an usually high rate, i.e. we would expect 1 in 5 staff members to leave each year. So the current requirement for six-monthly fire drills (as per the Fire Safety and Evacuation of Buildings Regulations 2006), and 3 monthly for ECCs, seems satisfactory.

Child evacuation research

The research on evacuation speeds for young walking children is consistent. Speeds down stairs are typically between 0.1 m/sec for the under-twos and 0.6 m/sec for those over four, and faster for older children. In the absence of data for New Zealand, these ranges are used in the next chapter to estimate evacuation times for ECCs at various levels of a multi-story building. There was no data found on the speeds of adults carrying children down stairs. These could be quite fast, i.e. at an unburdened adult speed of 1.0 m/sec but is more likely to be slower than this.

Evacuation speeds for under-twos are estimated at 1/10th the speed for adults.

Guidance documents

These guidance documents mainly relate to on-going use of the building rather than the initial provision of safety measures and equipment. They cover hazardous materials, maintaining equipment, signs and escape paths, and staff / occupant training. However, some guidance relates to recommendations on appropriate floor level of occupancy, and built-in safety measures including fire ratings, sprinklers, detectors and alarms. These passive and active measures are best included in the initial construction. It is unclear how often additional measures (i.e. above building regulation) in the guidance documents overseas are actual incorporated into their new buildings. It seems likely additional fire safety is not included due to expense.

6. EVACUATION ANALYSIS

Current Acceptable Solution requirements for childcare centres above ground floor level in New Zealand include sprinklers, two places of safety directly linked to separate escape paths, and alarms and detectors.

6.1 Evacuation from existing older buildings

The requirement for two places of safety is a recent amendment (effective from July 2014) and most ECCs in multi-story buildings would not have these. It is known that at least one ECC is at level 6 in a multi-story building that is higher than 6 stories in total.

This raises the question: What is the likely evacuation time of children of varying ages from level 6 in existing buildings?

Walking children

Assume a travel speed down stairs of 0.1 m/sec for the youngest walking child. From level 6, 10 metres of stairs per level, this takes about 10 minutes, plus another 6 minutes readiness time (detection, notification, pre-movement). The readiness time is from C/VM2 Table 3.3 allowing for 1 minute staff response plus 1 minute for each child per staff member, assuming a 5:1 ratio. There is also some minor horizontal travel time from the floor of occupancy, so no more than 20 minutes in total. The FRR of the stairway in a building this high would typically be about 60 minutes. So the factor of safety would be approximately three, which seems to be reasonable.

However, the younger walking children may find descending all six stories difficult, even at the slow 0.1 m/sec assumed. Some are likely to stop for rests, could possibly fall as they tire, and may require carrying by staff. Further, these children would slow the evacuation of all occupants. If there are occupancies above level 6, i.e. the building is greater than 6 stories, then the available time may not be sufficient for people above level 6. The building designers would not be aware that pre-school children are occupants and could slow evacuation to below the rate assumed in the design.

Younger walking children may find descending all six stories difficult, and may stop for rests, fall as they tire, or require carrying by staff.

The second major concern are the non-walking children which need to be carried by staff. Various methods for this have been trialled including:

- Staff relays from floor to floor.
- The use of shoulder harnesses or carry cots (2 or more children per staff person).
- Staff carrying one child each.

Non-walking children

For the staff carry option (1 child per person), assume an ECC on level 6, 15 non-walking children, 3 staff, and a carrying adult carrying speed of 0.4 m/sec on stairs. Assume they evacuate 1 ½ levels at a time so that 5 children are stored on each of 3 landings. Each person carries 5 children over 1 ½ levels in a leapfrog fashion. The total travel time is

about 24 minutes from level 6 to level 0 plus 6 minutes preparation time. This gives a total evacuation of 30 minutes and the factor of safety reduces to two. In this option, staff are returning against the evacuation flow of other occupants (which the NZSF discourages). Further, the landings at any one time have 4 carry cots which further impedes evacuation of others. We conclude ECCs at level 6 are impractical with this number of non-walking children and staff, and this method of evacuation.

For this example the main solution would be to have lower child to staff ratios (say 3:1) and have staff carry 3 children at a time (in an apron and backpack arrangement). In that case all staff movement is downward, and total evacuation time would be less than 10 minutes.

6.2 New builds compliant with latest regulations

In newly designed tall buildings, the intention is the children would initially be moved to the places of safety of the same floor while the situation is assessed. Then the opinions are:

- Evacuate immediately.
- Remain in the place of safety until the rest or the building has been evacuated or until the fire service assists in evacuation.
- Remain until the fire had burnt-out or been extinguished.

If the latter assumptions are not the case, then assuming a 15 story building (FRR =60 min), all adults would take about 10 minutes to exit (including preparation time). The NZFS could probably evacuate all children after that in another 12 minutes (assuming for each fire person 3 return trips, 1 child per trip, ECC on 6th level). This would give a total of about 22 minutes evacuation time which is marginally unsafe (using FS=3).

It is concluded that ECCs at level 6 are about the limit for safe evacuation. However, child-staff ratios would need to be lower than 5:1 in case the NZFS is unable to assist.

ECCs at level 6 are about the limit for safe evacuation but child-staff ratios would need to be lower than 5:1 in case the NZFS is unable to assist.

The performance of the place of safety relies on fire separation and smoke barriers. In theory, the fire separation between the refuge and the area on fire is sufficient to contain the fire until burn-out. In practice this may not occur, and there may be only a finite time available within the place of safety. Also, the place of safety may not be totally effective because of smoke inflow.

The above calculations have suggested a 10 minute stay in the place of safety before evacuation by the fire service. Failure before this time seems unlikely though smoke entry could be an issue. Consideration should be given to positive pressure ventilation to maintain the integrity of the places of safety.

What is the evacuation procedure for buildings with new designs? Will the children remain in the places of safety regardless of story level?

For ECCs up to six stories in new buildings it is likely staff will be tempted to evacuate regardless of what their evacuation plans say. In an emergency there will be parental pressure to “save my child”, particularly when they are only a short distance above

ground level and they can see a fire at higher levels. It may be unreasonable to expect delayed evacuation in this situation. That makes the evacuation chaotic as there will be a mix of occupancies exiting together, and the fire drills may not have covered that situation.

The authors are not persuaded that ECC personnel would always delay egress until all other occupants have evacuated. Also, staff cannot rely on NZFS personnel to assist because that is not their first task. We are suggesting the places of safety may not provide extra security in the event of fire in some cases. However, the authors support maintaining their requirement as per C/AS4 because we assume most ECC will follow the evacuation plan. We recommend adding positive ventilation to the requirements for places of safety.

Fire engineers design buildings using the acceptable solution or a verification method, which are based on rational theory and testing. They point to no major fires in multi-story buildings for many years. (Ballantynes 1947 the most recent), suggesting current practices are adequate. The highest known ECC in New Zealand is at level 6 and an evacuation drill in this building was very unsatisfactory on their first attempt, as observed by the NZFS. Problems included lack of staff training and confused children. Subsequent drills improved the evacuation time and child acceptance of the process. This reinforces a theme in guidance documents about the need for regular practice.

In drills, the child-adult ratios are often below the 5:1 normally required by MoE and other occupants do not always simultaneously exit.

In these drills the child-adult ratios were below the 5:1 normally required by MoE for under 2's, and other occupants were not simultaneously exiting. If the child-adult ratios were reduced below the default MoE requirements and/or the NZFS is able to quickly assist, then evacuation of non-walking children could be safe at quite high stories.

The authors accept these arguments, assuming staff are well trained and safety measures work as expected. . But things can go wrong in an emergency. For example:

- There could be insufficient staff at the time.
- Staff could be temporarily incapacitated.
- Mixed occupancy evacuations (i.e. children and adults together) are not practiced and could cause confusion among the children in a real emergency.
- The fire service could be delayed.
- The fire could be more intense than building design allows for.
- Passive and/or active measures could fail.
- Places of safety are not used as designed.

Any one of these occurrences could affect the safety of the ECC. For that reason it is recommended the regulations be very conservative for ECCs, particularly as vulnerable young children are involved. It seems the best way to do this is to limit the story level for ECC in combination with a decrease in the child-staff ratio for ECCs in multi-story buildings.

7. RECOMMENDATIONS

Incorporating the analysis of international best practice, discussions with the Fire Service, and the evacuation analysis, the recommendations are:

Physical characteristics of the building

- The places of safety, and exit paths, should be adequately pressurised to ensure no smoke entry, for all new ECCs in new and existing buildings.
- These recommendations be enacted in the building regulations.

ECC occupancies and preparedness

- ECCs, for all age groups, be located no higher than level 4 (where level 0 is ground level), for all new ECCs, in new and existing buildings.
- All staff should be willing and able to carry children downstairs as an employment condition, and in accordance with the evacuation plan, for all ECCs above ground.
- MoE and NZFS should ensure that evacuation procedures for existing ECCs above ground level are satisfactory. Further, they should ensure that monthly trial evacuations are done and records kept of evacuation times and problems.
- Final approval for new ECCs in new and existing buildings should be conditional on the execution of a satisfactory evacuation drill as observed by the NZFS.
- The NZFS and MOE should annually jointly observe an **unannounced** evacuation drill for at least one ECC, above level 2, involving evacuation of the whole building. They should consult over any lessons learnt and whether any changes in regulation and guidance documents are needed.
- Repeated failure of evacuation drills by any particular ECC should be published.

Evacuation scheme design

- The design of the fire evacuation scheme for each ECC should assume:
    - Factor safety of 3 on evacuation time compared to the FRR of the escape route.
    - Each staff member is able to carry 20kg of children (in a backpack, cot, or harness).
    - Evacuation speed of the youngest walking child is 0.15m per sec, staff carrying children 0.6 m/secec, and other building occupants 1 m/secec. If places of safety exist for ECC assume that these are evacuated after other building occupants have completed moving past the ECC floor levels.
    - Evacuation from the ECC occurs after all other occupants have evacuated.
    - For consistency these factors should be the same for all ECC designs.
    - Consider the use of parents working in floors above the ECC as assisting with evacuation, including full participation in training and practice drills.
    - Downstairs movement only is allowed, i.e. staff return upstairs to assist is not acceptable.

- The above criteria will often mean the child:staff ratio for under 2's needs to be below the current MoE minimum of 5:1.

- More strictly objective criteria are to be developed for assessing a "satisfactory" evacuation drill. These criteria should be jointly developed by the NZFS and MoE. The criteria should consider:
  - Appropriate child to staff ratios for various age groups.
  - Evacuation time.
  - Use of "places of safety".
  - Staff and child behaviour during evacuation.
  - Supervision at the ground level places of assembly.
- The evacuation plans should include identification of an assembly place at ground level. The supervising staff at ground level should have a system to keep children save from traffic and other dangers.

8. INTERVIEWS WITH FIRE SERVICE PERSONNEL

8.1 Interview A: Senior Station Officer and Fire Safety Advisor

The interviewee had experience both at an operational level having risen to the rank of senior station officer, and at a strategic level, now occupying a role in Fire Safety. The interviewee has attended numerous trial evacuations and instances where fire alarms have tripped leading to evacuations.

Approval of evacuation plans is responsibility of the NZFS and MoE

Interviewee A explained that evacuation plans for buildings must be approved by the NZFS and consider:

- Installation of an early warning / fire alarm system
- A trial evacuation that demonstrates:
    - Clear organisation.
    - Clearly-identified wardens.
    - Designated evacuation points.
    - Timely evacuation periods.

The MoE must also issue an evacuation licence to the ECC, and will take the NZFS view on the adequacy of the evacuation plan into account in issuing it.

"Prepped" trial evacuations may not be close enough to the "real thing"

Interviewee A was concerned that in the case of trial evacuations of ECCs, the students had been "prepped" for the specific evacuation. The Interviewee was concerned that an unplanned evacuation in case of fire might be significantly less organised. Even more concerning was that, in a trial evacuation of a building including an ECC several floors up, there were clear logistical challenges. The children were slow in evacuating, took up large amount of space going down stairs, and clogged up both stair wells. The management plan called for older children to evacuate first but this did not massively improve speeds.

Nevertheless, the evacuation was completed within the required time limits. Again, the interviewee was concerned that in a real fire situation, where children and adults could smell smoke, there could be serious risks to rapid evacuation.

There were a number of other evacuation-related concerns

Interviewee A highlighted several other evacuation-related concerns including a lack of coordination between the ECCs in a high-rise and other tenants. Better planning together could mitigate some of the risks associated with slower evacuations. Further, he was concerned that as adults and children come down the staircase from higher floors, more adults would join from lower floors, leading to congestion and mixing up children with faster-moving adults. Finally, ECCs with under-twos may need to evacuate when young children were asleep, leading to further delays as they would be groggy and would need to get ready to go outside.

Suggested measures

A number of possible solutions were discussed, some of which were building-related, while others were evacuation-related. In many cases, there were both pros and cons to each solution.

- Insist on sprinklers on all buildings (old and new).
- Create positive pressure stair wells (although this makes it noisier which may concern small children).
- Include a lift just for use by the ECC but as many fires start in lift wells, this may not be suitable.
- Use staged evacuation alarms with early warning to avoid the time and productivity losses of unnecessary full-building evacuations.
- Conduct unannounced evacuations, whereby the NZFS would monitor unplanned evacuations although other tenants would likely find the unplanned disruption to their businesses and associated production costs unpleasant.
- Assign NZFS personnel to assist on particular floors where ECCs are located in the event of an evacuation. This would require NZFS personnel to enter the building and move against the flow of people up the stairs.

One related question discussed was what the implications of an ECC failing an unannounced trial evacuation would be. There would need to be sufficient incentive to ensure ECCs were well prepared for an unannounced evacuation, which is always the intention anyway. Interviewee A pointed out that the MoE can suspend an ECC's licence if it believes there is a safety risk to the students. Further, the NZFS can shut an entire building down if it believes the risks are too high, provided a district court judge agrees.

Making ECCs and building owners aware of these risks if they do not have sensible, well-practised evacuation plans in place, and introducing regular unannounced trial evacuations may be the best solution.

8.2 Interview B: Fire Risk Area Managers

These interviewees had experience both at an operational level, and at a strategic level, with medium and high-rise building experience.

Most ECCs are purpose-built buildings with children below level 3

In the CBD, the managers know of 3 ECCs that that are not on the ground floor. One is on 2 floors at level 5 and 6. In the smaller centres, there are none above level 1 (i.e. maximum 2 story buildings). Most are purpose built and they expect more to be built in both the CBD, and town centres and suburbs, due to parental demand.

Evacuations may be poor even if the plan looks OK

Two level evacuations are all OK, though some are much better organised than others. An observed 6th level evacuation was a "dismal failure". The paper process, i.e. evacuation scheme, was OK, but the actual drill was very poor. Issues included:

- Staff being unaware of their roles or came up from a lower level.

- Children appearing uncertain of what was expected.
- Herding children down stairs was difficult and slow.
- The stairwell lights cutting off after a few minutes.

The observers had evidence that two staff members were just in for the day (they had advance warning) to assist with the evacuation. This made the trial evacuation an unfair representation of reality. This is potentially dangerous.

A second trial drill was better conducted and executed.

Strengths and weaknesses of current regulation re ECC

The MOE requirement for minimum child:staff ratios is a good tool for expediting evacuation if staff are well trained and always on site.

Current weaknesses include:

- The NZFS is required to approve the evacuation scheme and fire safety measures before the building consent is issued. But they need to see a trial evacuation to identify problems in the evacuation.
- The fire engineer can produce an adequate design for evacuation. Assuming the drawings are followed in construction then there should be no issues with evacuation. But occasionally unforeseen hazards arise in the new built and the evacuation design does not work as well as expected.
- It is sometimes necessary to see a building soon after first occupancy to check various features. Features include ground level exit, signs, operation of alarms, hazardous materials, and talk to the building's fire safety supervisor.
- The approval of evacuation schemes involves a check box approach, by non-frontline firefighting staff (in the NZFS Information Unit). The owner fills out information on building use, size, age and fire protection measures. However, some (3 pages out of 18) of this is voluntary and many owners provide no information in the voluntary section. This section covers use/occupancy, number of occupants by floor, single/ multi-storey, occupancy hours, and any part closed-off and not occupied. All of this could be useful information in the event of drills and actual fires.

International best practice is mixed

The Interviewees believed that not many countries allow ECCs on upper levels. New Zealand compares quite favourably on child:staff ratios. Crèches in retail centres overseas are a problem e.g. Dubai. The Interviewees foresee similar potential problems here in New Zealand, even though most ECCs in NZ retail centres are on the ground floor or level 1.

Ongoing monitoring of building and occupancies is required

Local Councils are responsible for issuing the certificate of compliance (COC) to the building owner. But the building owner is not usually on site and won't know the day-to-day happenings that may affect compliance. If the owner does not use a fire safety

company to monitor drills and compliance, then the onus falls on the building manager, who may not have the right skills.

The Interviewees suggested more responsibility be placed on the building occupants to ensure the requirements of evacuation schemes are followed. When there are issues, then the occupants should provide information which should be used to update the COC.

Levels of compliance need work

The Interviewees felt that levels of compliance were not as high as they should be as the owner is usually off-site and is not aware of fire safety issues. Some owners use a fire safety company to monitor equipment and trial evacuation performances. Often, it is the same company that developed the evacuation plan. However, there is an apparent conflict of interest since the evacuation plan designer may be reporting back to the owner and NZFS on the success, or otherwise, of the evacuation drill.

9. APPENDIX – OLSSON FIRE ENGINEERS REPORT

Olsson Fire & Risk
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International Childcare Fire Requirements

Research Summary

Revision: 1.1

C14100P

We
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Executive Summary

Olsson Fire & Risk
CONSULTING ENGINEERS • NEW ZEALAND

Olsson Fire & Risk Ltd has been appointed by BRANZ Ltd. Our task is to review and summarise the specific fire design requirements for single and multi-storey child care centres in the follow jurisdictions: NFPA, IBC, UK, Australia, Ireland, Singapore, Norway, Sweden, Finland and Denmark. The standard (usually prescriptive) design requirements have been found by consulting practising fire engineers in each region. The following tables summarise the design requirements provided by these engineers for a single storey building whose sole occupancy is a child care facility and a multi storey building whose sole occupancy is a child care facility respectively. It must be noted that these requirements may change is the building includes occupancies with a different use to the child care. For the main regions (US, UK, Australia) background information has been included regarding to the fire requirements including which organisation (building legislation or healthcare/education requirements) provides guidance on design and operational fire requirements.

Summary of Key Findings and Assumptions

1.1.1 US Requirements

There are a number of parameters in the US codes (International Building Code (IBC)) that impact the basic questions. In particular, the construction classification can vary greatly and depends both on the height of the occupancy but also the area. Therefore, for this comparative study it has been assumed that the single story child care center would be approximately 10,000 square feet (930 m^2), and the multi-story facility would be about 10,000 square feet (930 m^2) per floor to provide a baseline. Also, there are some provisions for direct exiting that would allow the occupancy classification to change from Group I (Institutional) to Group E (Educational) if the child care area has less than 100 children and each space has an exit door directly to the exterior. As such, it has been assumed the single story facility would be Group E and the multi-story facility would be Group I-4. Furthermore, the age cut-off in the IBC for Group I occupancy is generally 2.5 years old. Children older than 2.5 years old would generally fall into Group E occupancy as opposed to a Group I occupancy. Finally, there are few operational considerations directly in the codes - procedures such as trial evacuations are found in requirements that vary by state and licensing organisations. For this study the child staff ratios recommended for US child care centers to achieve accreditation by the National Association for the Education of Young Children, although it must be noted that in some states, the child to staff ratio can be as high as 1:8 for children less than 18 months old.

1.1.2 UK Requirements

There are two main guidance documents in the UK for fire safety design; Approved Document B and BS 9999. Either of these codes can be applied in the fire safety design of a building. An Early Childhood Centre is typically considered a place of Assembly in the UK code guidance. Although Early Childhood Facilities are not mentioned specifically in the prescriptive guidance, comment is provided on the location of childcare facilities within larger buildings; a crèche in a shopping centre for example. The guidance states that these facilities should be located on the ground level or at a level that has direct access to outside (a final exit). Furthermore, child cares should be in a location where parents can collect them on their way out of the building thereby not causing counter-flow of other persons evacuating.

A document that provides design guidance on a facility such as a Nursery School, is *Building Bulletin 100: Design for Fire Safety in Schools*. This covers schools containing children from the age of 2 up to 19. The information in the table below concerning UK fire design of child care centres is based on this document.

The Department for Children, Schools and Families (DCSF) expects that a risk assessment be undertaken to assess the validity of providing sprinklers in a building.

The presence of a life safety grade sprinkler system enables larger compartment sizes, reduced separation distances to adjacent properties, mechanical ventilation to basement car parks in lieu of a vent to outside, fewer fire-fighting shafts owing to a greater distance permitted to fire mains outlets and lower fire resistance levels.

Building Management:

a. Building Regulations do not impose any requirements on the fire safety management of a building but it generally considered in the design process.
b. The DCSF has a risk management strategy for existing schools, the implementation of which has potential to reduce the insurance premium of the school.

Regions within the UK have different guidance documents and codes of practice on the day-to-day management of childcare centres, e.g. Scotland, Northern Ireland and England each have their own guides. They typically contain information on the treatment of children, the facilities they are provided with and the people that work in those environments.

1.1.3 West Australia

The relevant legislation and regulations that apply to childcare centres are only the normal building regulations.

- WA Building Act 2011
- WA Building Regulations 2012 – This enables the Building Code of Australia

There is a Health (Public Buildings) Regulations however this does not apply to early childhood centres. However kindergartens and pre-primary schools are. Childcare centres are not specifically defined in the BCA classification definitions, typically a building certifier will consider it a Class 9b (which includes schools).

The Deemed to Satisfy (DtS) Provisions do not have any specific requirements for childcare centre however Clause E2.3 of the Building Code of Australia – suggests that additional smoke control measures may be required for certain uses, mixes of classifications where they are not specifically addressed. This can be interpreted to mean childcare centres.

In West Australia due to the fire brigades (Department of Fire and Emergency Services , DFES) position that there should not be childcare centres above ground, Building Certifiers typically ask that the fire engineer directly assess the childcare centre and provide a strategy for evacuation. While this does not influence DFES, they are only an advisory body and the Building Certifier can choose not to accept their advice. Regarding multi storey and above-ground child care centres, it was also noted that one of the reasons for locating the childcare above ground is to alleviate concerns about security and the safety of the children.

Single Storey Childcare Requirements

Region	FRR	FRR Escape Routes	Staff : Child Ratio	Min. Number of Escape Routes	Horizontal distance to Exit	Sprinklers Req'd?	Places of Safety	Drills and Training
US	0 to 120 minutes depending on adjacent occupancy type and whether sprinklers are installed.	0 to 60 minutes depending on whether sprinklers are installed	Less than 18 months: 1:4 Less than 27 months: 1:6 Less than three years: 1:9	Each space requires at least one exit.	200 feet (61 m) without sprinklers, 250 (76 m) feet with sprinklers	Sprinklers required for fire areas exceeding 12,000 square feet (1115 m^2).	None required. Doors must open to the exterior directly (otherwise fire safety requirements become more onerous).	Monthly fire drill required involving all occupants.
UK	**Structural frame, beam or column:** Non sprinklered: 60 minutes Sprinklered: 30 minutes **Compartment walls:** Sprinklered/Non-Sprinklered: 60 minutes fire resistance	30 minutes	Less than 1 years old: 1 :3 Less than 3 years old: 1:4 3 years +: 1:8	1 exit is acceptable for less than 60 persons	Places of special fire hazard: 9 m in one direction / 18 m total Other areas: 18 m in one direction / 45 m in total Ground storey of small premises with one exit only: 27 m in total	Not usually, but is dependent on outcome of risk assessment.	None required	At least annually, preferably every school term.

Region	FRR	FRR Escape Routes	Staff : Child Ratio	Min. Number of Escape Routes	Horizontal distance to Exit	Sprinklers Req'd?	Places of Safety	Drills and Training
Singapore	Non sprinklered: 60 minutes Sprinklered: No rating required	Direct access to outside required (unless sprinklered)	2 months – 18 months: 1:5	1 exit for maximum 50 persons	**Non- sprinklered** One way travel: 15 m Two way travel: 30 m **Sprinklered** One way travel: 25 m Two way travel: 45 m	Optional	None	Not stipulated
Finland	Min. EI30, Max R60	EI 30 minimum.	Less than 3 years old; 1:4 More than 3 years old: 1:7	2 exits (for small e.g. 100 m2, 1 exit and 1 fire escape	45 m	No	None required	Safety plan must be known to staff. 1-2 drills per year.
WA	120/-/-	Direct exits are typical, so not applicable	Less than 2 years old: 1:4 Less than 3 years old: 1:5 More than 3 years old: 1:10	1 exit however this reduces Total Open Path (TOP)allowed to 20 m.	20 m single direction (DEOP) 40 m – total escape path length (TOP) If one exit, 20 m TOP	No	None required	Annually
Sweden	R30	EI 30	No regulations as this varies by municipality, but usually 1:5 to 1:6		30 m	No	None required	None stipulated

Region	FRR	FRR Escape Routes	Staff : Child Ratio	Min. Number of Escape Routes	Horizontal distance to Exit	Sprinklers Req'd?	Places of Safety	Drills and Training
Ireland	30/30/30	Direct exits only	Less than 1 years old: 1:3 1-2.5 years old : 1:5 2.5 – 6 years old: 1:10	2 if > 20 children or horizontal distance to exit requirements exceeded.	Single Exit: "Active" children: 18 m Sleeping children: 10 m Min. 2 Alternative exits: "Active" children: 45 m Sleeping children: 20 m	No	None required	Monthly fire drills required.
New South Wales			Less than 2 years old: 1:4 Less than 3 years old: 1:5 (currently 1:8, until 31/12/15) More than 3 years old: 1:10	2 exits minimum. Horizontal exits (into neighbouring firecell) not permitted	20 m single direction 40 M total in more than one firection If one exit, 20 TOP	No	1 required	
Norway	EI 30 (R30 for loadbearing walls)	EI30		If less than 150 people in building, 1 exit is acceptable.	50 m	No	None required	Annual fire drills
Belgium	"Low" buildings (<10 m) REI60	REI60	1: 8	Not specified in legislation	30 m	No	None required	Annual fire drills
Denmark	REI60	Exits to be direct to outside	Not stipulated	2 escape routes: either to outside or doors in opposite directions. Exit windows acceptable.	25 m	Not required, unless area of sleeping occupants is greater than 100 m^2	None required	Recommended but not required

Multi Storey Childcare Requirements

Region	FRR	FRR- Escape Routes	Staff : Child Ratio	Number of Escape Routes	Horizontal distance to stairs	Sprinklers Req'd?	Places of Safety	Drills and Training
US	1 to 3 hrs depending on adjacent occupancy type. It does not depend on building height unless a higher floor rating is required for the base type of construction.	No rating. Sprinklers are required.	Less than 18 months: 1:4 Less than 27 months: 1:6 Less than 3 years: 1:9	Each space requires at least one exit.	200 feet (61 m) with sprinklers.	Yes	None	A fire drill is required quarterly on each shift for Group I occupancies. Only employees are required to participate.
UK	**Structural frame, beam or column:** Non sprinklered: 60 minutes Sprinklered: 30 minutes **Compartment walls:** Sprinklered/Non-Sprinklered: 60 minutes fire resistance	30 minutes	Less than 1 years old: 1:3 Less than 3 years old: 1:4 3 years + : 1:8	1 exit for up to 60 persons. It is noted that the childcare should be sited on the same level as the parents or guardians or on route to the final exit.	**Places of special fire hazard**: 9 m in one direction / 18 m total **Other areas:** 18 m in one direction / 45 m in total **Ground storey of small premises with one exit only**: 27 m in total	No	None	At least once a year, preferably every school term.

Region	FRR	FRR- Escape Routes	Staff: Child Ratio	Number of Escape Routes	Horizontal distance to stairs	Sprinklers Req'd?	Places of Safety	Drills and Training
Singapore	Non sprinklered: 60 minutes Sprinklered: No rating required.	60 minutes..	2 months – 18 months: 1:5	1 exit for maximum 50 persons. Upper storey child care centres shall be sited adjacent to an exit staircase with direct dedicated access through smoke-stop lobby to the staircase (minimum one exit staircase) or direct access without passing through the common areas to the exit staircase	**Non- sprinklered** One way travel: 15 m Two way travel: 30 m **Sprinklered** One way travel: 25 m Two way travel: 45 m	Optional	None	Not stipulated
Finland	Min. EI60	EI60	Less than 3 years old: 1:4 More than 3 years old: 1:7	2 exits (for small e.g. 100 m2, 1 exit and 1 fire escape	45m	No	None	Safety plan must be known to staff. 1-2 drills per year.
WA	120/-/- (Only structural rating required)	120/120/120	Less than 2 years old: 1:4 Less than 3 years old: 1:5 More than 3 years old: 1:10	1 escape route minimum (reduces escape distance to 20 m)	20 m DEOP 40 M TOP If one exit, 20 TOP	Sprinklers, stair and zone pressurisation required for buildings above 25 m.	None	Annual
Sweden	R60	EI 60	Not stipulated	Minimum 1 exit	30 m to Exitway	No	None	None stipulated

Ireland	EI30	EI30 if greater than 2 storeys	Less than 1 years old: 1:3 1-2.5 years: 1:5 2.5-6 years: 1:10	2 exits required if > 20 children o open path escape length requirements exceeded. No more than 20 children permitted on upper storey with a single exit	**Single Exit:** Active children: 18 m Sleeping Children: 10 m **If 2 or more exits:** Active children: 45 m Sleeping Children: 20 m	No	None	Monthly, as well as at the start of each school y ear
NSW	120/-/- .Above ground childcares are not encouraged – specific design and/or additional provisions may be required.	120/120/120	Less than 2 years old: 1:4 Less than 3 years old: 1:5 (currently 1:8, until 31/12/15) More than 3 years old: 1:10	2 exits minimum. Horizontal exits (into neighbouring firecell) not permitted	20 m single direction 40 m total in more than one direction If one exit, 20 TOP	Yes, if in a mixed class building		3-6 monthly if children are sleeping over, otherwise "regular "trials are required
Norway	2 storeys: 30 mins 3-4 storeys: 60 minutes >= 5 storeys: 60 mins, and including only non-combustible materials	2 storeys: 30 mins 3-4 storeys: 60 minutes >= 5 storeys: 60 mins, non-combustible materials	This is stipulated by municipality based on the needs of the children, and is not a fire requirement. The number of staff must "be sufficient to enable all staff to carry out satisfactory educational activity."	For 2 storey buildings, 1 stair case is acceptable if there are also "escape windows," with a height of max 5 m to ground. Alternatively 2 enclosed staircases are required. For three or more storeys, 2 enclosed staircases are mandatory	50 m Total Open Path (TOP)	If > 3 storeys (residential or standard sprinklers)	None	Drills to be run annually Children are not required to be part of the evacuation drill.

Belgium	"Medium" Buildings (10 m < H< 25 m): REI 60 No day-care allowed above 25m or below ground level.	REI60	1 : 8	1 exit is sufficient	30 m	Not required unless diverging from prescriptive requirements	None	Annually
Denmark	REI120	REI120	None stipulated	2 escape routes, either directly to the outside, or doors in opposite directions.	25 m	Yes	None	None stipulated

Relevant Legislation and Guidelines by Region

Region	Code Requirements	Other Requirements where applicable
US	The IBC and IFC codes, NFPA 101 depending on whether the specific state adopts it	Stipulations provided by the relevant licensing organisation such as the Joint Commission on Accreditation of Health Care Organizations (JCAHO).
UK	Approved Document B (Fire safety) – Volume 2 - Buildings other than dwellinghouses (2006 edition incorporating 2010 and 2013 amendments) The Regulatory Reform (Fire Safety) Order 2005	Fire Safety Risk Assessment: Educational Premises
Finland	E1 The National Building Code of Finland: Fire safety of buildings, Regulations and guidelines 2011.	Additional guidance published by Ministry of the Environment (responsible on fire regulations)
Singapore	Singapore Fire Code 2013	Child Care Centres Act 2012. Guidance provided in "Guide to Setting up a childcare centre" provided by Early Childhood Development Agency
WA	WA Building Act 2011 WA Building Regulations 2012 – This enables the Building Code of Australia	Department of Fire and Emergency Services (non legislative, advisory body, does not support above ground child care facilities)
Sweden	National Board of Housing, Building and Planning's building code, BBR.	No other requirements
Ireland	Fire Services Act 1981, Building Control Act 1990,	Childcare (Pre School Services) Regulations 1996, Explanatory guide to regulations and procedures for notification and inspection
Norway	The technical regulations (function based) (English) – Chapter 11 regulates fire safety: http://dibk.no/globalassets/byggeregler/regulations_on_technical_requirements_for_building_works.pdf . The pre accepted regulations (only exists in Norwegian): http://dibk.no/no/BYGGEREGLER/Gjeldende-byggeregler/Veiledning-om-tekniske-krav-til-byggverk/	Norwegian Day Care Institution Act
Belgium	Appendices to the Royal Decree 1997	
Denmark	Guideline - "Energistyrelsen, Eksempelsamlingen om brandsikring af byggeri (Danish)	Alternative to guide is performance based design

Discussion

It is worthy of comment that the variation in requirements represents the development that has occurred in each jurisdiction.

Where there has been research or recognition of the issue (Childcare centres on upper levels of multi storey buildings) the various licensing and regulatory response is to legislate for these. Where there is not a perceived issue (childcare centres are commonly located in single storey buildings) then there has been no legislative response.

The background to the recent changes to the NZ requirements relating to Childcare Centres is in response to a rise in the number of childcare centres being proposed, or indeed, located in multi storey buildings. Licensing, Fire Service and Regulatory Authorities in NZ were concerned about the safety of children in such a situation, particularly in relation to the need to escape down stairs being supervised by child care staff with a ratio of up to 1 to 6 children. These children could be of any age between 0 and 6 years.

Whilst sprinkler protection of the building mitigates against a fire starting on other floors of the building, if the fire originates on the child care floor then the occupants would have to evacuate. Hence the need for the ability to evacuate horizontally to a protected space giving time for evacuation down stairs to be organised and managed for the benefit of the occupants of the childcare centre and the rest of the building.