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A pilot study exploring the measurement of intergenerational differences in independent mobility

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ABSTRACT

Background: A fundamental issue limiting the understanding of children's independent mobility (IM) is the absence of a standardised measurement method. This pilot study explored the use of three different measures of IM to assess intergenerational change and investigated social perceptions in children's unsupervised roaming.
Methods: Data were collected for 45 participants from three directly-related generations. IM was assessed and analysed in all participants using three measures; IM Licence (permission to travel unsupervised), IM Index (the summed score from multiple items on a questionnaire) and IM Maximum (maximum roaming distance from participants' residential addresses located on Google Maps). Qualitative data were collected from all participants regarding perceptions of IM.
Results: Significant correlations between IM Index and IM Maximum were observed for child participants (R^2=0.334) but not for parents (R^2=0.024) or grandparents (R^2=0.284). IM Licence was not comparable with either IM Index or IM Maximum. Decreases in IM from grandparent to child were observed for all three measures of IM, with some children experiencing extremely low levels of IM.
Conclusion: The results highlight the need for a standard measurement protocol for IM that facilitates comparability among studies. Maximum IM distance estimated via web-based interactive mapping may be a promising choice in this respect.

1. Introduction

Children with increased freedom to play and travel in their neighbourhood without adult supervision (independent mobility) (Hillman et al., 1990; Shaw et al., 2013; Broberg et al., 2013; Mammen et al., 2012) may experience numerous social and physical benefits (Hillman et al., 1990; Shaw et al., 2013; Mikkelsen and Christensen, 2009; Pooley et al., 2005). Independent mobility (IM) is fundamental to children's psycho-social development through the facilitation of cognitive skills (Burdette, 2005; Tamis-LeMonda et al., 2004), social prowess (Brown, 2009; Ginsburg, 2007) and emotional intelligence (Bunker, 1991). Children's IM also provides an important opportunity for the daily accumulation of physical activity that benefits children's short- (Brockman et al., 2010; Janz et al., 2010; Slutzky and Simpkins, 2009) and long-term (US Department of Health and Human Services, 1996; Habib and Saha, 2010; Blair et al., 2007) health. It has been suggested that children with reduced unsupervised exploration are missing out on opportunities to develop resilience and life-skills for the adult world (Gill, 2007; Mackett et al., 2007) and experience lower physical activity levels than those with increased IM (Brockman et al., 2010; Stone et al., 2014; Page et al., 2009; Wen et al., 2009; Ducheyne et al., 2012).

Despite the potential benefits of IM, investigation of children's IM over the last 40 years indicates a drastic intergenerational decline. Hillman et al. (1990) landmark study found substantial decreases in a range of English children's IM Licences (permission to roam on their own) from 1971 to 1990. These IM Licences reflected how children get around (on foot) on their own including licences to cross roads, to come home from school, to go places other than school and go out after dark. The IM Licences also related to the forms of transport

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available to young children; being able to cycle on public roads and use buses on their own. Two subsequent English studies conducted in 2000 (O'Brien et al., 2000) and 2010 (Shaw et al., 2013) using the same IM Licences found further decreases in children's independent roaming. Particularly noteworthy was the decrease in children aged 7–11 years old going home from school without adult supervision, which dropped from 86% in 1971 to 35% in 1990, decreasing further to 25% in 2010 (Shaw et al., 2013). Similar reductions have been found in other countries, including Germany (Shaw et al., 2013), the Netherlands (Karsten, 2005), Denmark, Finland, and Norway (Fyhri et al., 2011). Furthermore, recent studies in Australia (Veitch et al., 2008) and New Zealand (Freeman and Quigg, 2009) that have examined IM suggest that children today have very low levels of unsupervised roaming.

A number of pervasive social changes have propelled children's retreat from the streets. Exponential increases in global rates of car ownership have subsequently placed children at a persistent risk of enduring traffic related accidents (Collins and Kearns, 2001). A social trap has thus been created whereby concerned parents increasingly chauffeur their children by vehicle (Pooley et al., 2005), resulting in more traffic on the roads and fewer children on the streets. Additionally, neighbourhoods have experienced a reduction in social connections (Prezza and Pacilli, 2007), in part due to the increased ability to access areas further away from the local area; perceptions that neighbourhoods are less friendly have fuelled parental fear of strangers (Foster et al., 2014; Alparone and Pacilli, 2012). Media coverage of child abductions and crime has potentially amplified these fears, resulting in even less children roaming freely around local streets (Miller et al., 2008).

While several studies have investigated temporal changes in children's IM, it is difficult to compare findings due to heterogeneity in the ways IM has been defined and measured. Traditionally, children's IM has been assessed through self- or proxy-report of licences to roam unsupervised (Hillman et al., 1990; Shaw et al., 2013; Stone et al., 2014; Page et al., 2009; Ducheyne et al., 2012; Collins and Kearns, 2001; Pacilli et al., 2013; Tranter and Pawson, 2001; Veitch et al., 2014; Kytta, 2004). These licences reflect parental judgement of their child's ability to safely navigate the neighbourhood on their own. A key limitation of this method lies in the variation of how IM Licences are conceptually defined. Different aspects of IM Licences have been investigated including allowances (Hillman et al., 1990; Shaw et al., 2013; Tranter and Pawson, 2001), frequency of licences and destinations visited (Stone et al., 2014; Page et al., 2009; Pacilli et al., 2013), actualised affordances (Kytta, 2004) and territorial range (local and wider IM) (Page et al., 2009; Veitch et al., 2014). Consequently, comparability between these studies has some limitations. In addition, there have been inconsistencies between studies using IM Licences, in how the term *unsupervised* has been defined. In some studies there has been a focus on either a presence or absence of adult supervision (Hillman et al., 1990; Shaw et al., 2013; Ducheyne et al., 2012; Pacilli et al., 2013; Tranter and Pawson, 2001; Kytta, 2004) and some studies have incorporated the accompaniment of either siblings or friends in the definition of independent mobility (Stone et al., 2014; Page et al., 2009; Collins and Kearns, 2001; Veitch et al., 2014).

Assessment of active transport behaviours to and from school has also been used in previous studies as an IM indicator (Mammen et al., 2012; Mackett et al., 2007; Yang et al., 2014; Schoeppe et al., 2014; De Meester et al., 2014; Christian et al., 2014). The school journey provides a clearly defined episode of mobility, however it may not be undertaken independently. The school journey follows a route often predetermined by adults for which even active modes of transport may be supervised, such as through the use of walking school buses (Collins and Kearns, 2005).

Other studies have assessed children's real-time spatial movement via portable global positioning system (GPS) receivers (Mavoa et al., 2011; Quigg et al., 2010; Christensen et al., 2011; Barker et al., 2009). GPS receivers provide an objective measure of positional location and can accurately monitor individual journeys while removing participant bias (Stigell and Schantz, 2011; Duncan and Badland, 2009). However, a significant drawback of GPS is their inability to differentiate between supervised and non-supervised activity.

Map drawing is an alternative technique that has the potential to assess both children's licences to roam unsupervised in their neighbourhood, the distance they travel independently and to collect more complete data on the level of supervision. A number of studies exploring children's IM have utilised map drawing to facilitate the recall of travel licences (Veitch et al., 2008; Villanueva et al., 2013), perceived neighbourhood boundaries (Odgers et al., 2012), and roaming distances (Broberg et al., 2013; Freeman and Quigg, 2009; Badland et al., 2011). Recent advances in the development of online mapping have allowed a more interactive process that can assist in accurately recalling independent licences and distance travelled while acquiring further information on perceptions, experiences and environmental knowledge (Freeman and Quigg, 2009; Chaix et al., 2012; Kyttä et al., 2012; Rissotto and Tonucci, 2002). Unlike static maps which previous studies have relied on (Veitch et al., 2008; Villanueva et al., 2013; Badland et al., 2011), an additional benefit of online mapping is that neighbourhood size is not predetermined or restricted. Although there are a number of benefits for using interactive mapping to assess children's IM, it is still in its infancy and there is currently an absence of a single standard definition of IM using this method.

It is apparent that a significant issue limiting the understanding of children's IM is the variability in the conception definition of IM and the absence of a standardised measurement method. There is the need to understand differences and relationships between different measures of IM and whether these vary from child and parent perspectives. The aims of this pilot study were to (1) explore the use and comparability of three different measurement techniques to assess current and historical changes in children's IM over three directly related generations and (2) to assess the social perceptions potentially limiting children's IM today.

2. Methodology

This cross-sectional pilot study was conducted in Auckland, New Zealand in August 2011 using a mixed methods approach. Written, informed consent and assent were required prior to participating in the study. Ethical approval was obtained from the AUT Ethics Committee (AUTEC 11/121).

2.1. Participants

A convenience sample of participants was recruited through existing professional and personal contacts. Participants who met the eligibility criteria were invited to participate and provided written informed consent and assent. Children aged 10–12 years old were eligible; inclusion criteria for the parents and grandparent were to be gender-matched and directly related through the same genetic line as the child participant.

2.2. Procedures

Data were collected in each participant's home by a trained researcher; in the first instance with the child and parent, and in the second instance with the grandparent. Each participant took part in a semi-structured interview which included demographic questions, three measures of IM, and questions regarding perceptions of IM. The children's data were collected independently, without the presence of their adult relatives.

2.3. Measures

Demographic information was collected during the adult interviews. The number of working vehicles, bicycles and child mobile phone ownership was determined. The researcher made notes in regards to urban design including the type of house, street and if there was a back garden.

For all IM measures the child participants reported their current IM allowances and mobility. The parent and grandparent participants recalled their experiences as a 10–12 year old. To assess IM Licence, each participant was asked if they were allowed to go out on their own in the local neighbourhood. They were given the following options as responses: (1) yes, (2) no – only with other children, (3) no – only with an older sibling and (4) no – only with an adult. If 'yes' was answered, participants were then asked "If yes – is there/was there a time limit you are allowed out for". The children's and adults responses were cross referenced by asking the parent/guardian the same question in context "Was your child allowed to go out on his or her own in the local neighbourhood?".

Participants' degree of independent roaming in their neighbourhood was assessed using a questionnaire previously used in another international study to measure children's IM (Page et al., 2009). They were asked "how often are you allowed to go to the following places on your own or with friends (without an adult)?". For each location (local shops, big shopping centre, park, sports centre, swimming pool, library, school, cinema, friend's house, other outdoor places [beach, river, bush], bus stop or train station and local streets) participants were given the following scale to choose from: never, sometimes, often, or always. Participants were given an additional option of "I do not go there" for locations that are not available in the area. Each of the responses was assigned a rank (Never=0, Sometimes=1, Often=2, Always=3) and then summed to give a total score. The summed total was divided by the number of places the participant went to (excluding those answered "I do not go there"), which gave an overall IM Index.

Participants' maximum unsupervised roaming distance (IM Maximum) was assessed through the use of a computer assisted personal interview (CAPI), which took approximately five minutes. Using a laptop computer running the online application Google Maps, participants were assisted to plot their home and then identify the location which was the greatest distance from their home that they were allowed to roam unsupervised (without adult supervision or accompanied by friends/siblings). Using the mapping functions of the Google Maps software, the distance between this maximum roaming point and the participant's home was measured using the street network and following the most habitual route typically taken for this journey.

Participants' viewpoints and attitudes regarding children's current and historical IM were gathered during the semi-structured interviews. Key interview questions to engage conversation around parents and grandparents perspectives included: "are there (or were there) any reasons why your child is not allowed to go to certain places on their own?" and "do you think there is anything different from when you were 10–12 years old for your children today?". Questions for children included: "is there any reason why you do not like to go to certain places on your own?", "what do you think are your parents' reasons?" and "if you were allowed is there anywhere else you would like to go?"

2.4. Data analysis

Means and standard deviations for all descriptive data were calculated and differences between sexes examined using independent samples *t*-tests. One-way analysis of variance procedures with post-hoc testing was used to investigate differences in IM Index and IM Maximum among the three generations. Statistical significance was calculated using $P < 0.05$. Pearson correlations and regression analysis were conducted to assess the similarity between IM Index and IM Maximum. All analyses were conducted on SPSS (V. 17). No statistical comparisons were made between IM Licence and IM Index/IM Maximum, due to heavily skewed IM Licence data (see Section 3). Interview questions regarding perceptions were systematically analysed by generation for common themes.

Table 1
IM Index and IM Maximum for all participants and by gender.

		N	IM Maximum	IM Index
Child	Male	14	2796 (1281)	1.54 (0.59)
	Female	7	2428 (2957)	1.38 (0.9)
	Total	21	2673 (1929)*	1.49 (0.7)*
Parent	Male	8	7025 (6508)	2.4 (0.44)
	Female	9	3833 (2522)	2.1 (0.45)
	Total	17	5335 (4940)**	2.28 (0.44)**
Grandparent	Male	4	12,400 (5757)	2.75 (0.10)
	Female	3	1690 (1293)	2.26 (0.15)
	Total	7	7810 (7064)	2.54 (0.28)

* Significantly different from parents and grandparents ($P < 0.05$).
** Significantly different from grandparents ($P < 0.05$).

3. Results

A total of 21 children aged 10–12 years (14 male, 7 female), 17 parents aged 34–51 years (8 male, 9 female), and seven grandparents aged 62–73 years (4 male, 3 female) participated in the study. The majority of children (90%) lived in a single detached dwelling; two child participants lived in a unit. The children's homes were situated either on a residential street (66%) or a cul-de-sac (33%) and most (81%) had a back garden. Each family had an average of two vehicles and 4.6 bikes per household. Over half (62%) of the children owned a cell phone. The average number of children per household was 1.6 and 38% of the children had older siblings.

3.1. Independent mobility

3.1.1. IM Index and IM Maximum

Table 1 shows the IM Index and IM Maximum for the study sample. Mean IM Index for children was 1.49 (SD=0.7), parents 2.28 (SD=0.44) and grandparents 2.54 (SD=0.28). Males had a higher IM Index than females across all generations. While the mean IM Index decreased generationally from grandparents to parents to children, the difference was significant between parents and children only ($P<0.01$). The mean IM Maximum travelled by children was 2673 m (SD=1929) and ranged from 200 to 7000 m. The mean IM Maximum travelled by adult participants was 5335 (SD=4940) and ranged from 1500 to 22,000 m. Mean IM Maximum for grandparent participants was 7810 (SD=7064) and ranged from 270 to 17,000 m. Males had consistently higher IM Maximum than females across all generations. As with IM Index, generational differences in mean IM Maximum were significant between parents and children only ($P=0.029$).

Fig. 1 illustrates the relationship between IM Maximum and IM Index for children, parents, and grandparents. A significant correlation was observed between IM Maximum and IM Index for children ($\rho=0.568$, $P=0.007$) and across the pooled dataset ($\rho=0.452$, $P=0.002$), but not for parents ($\rho=0.117$, $P=0.655$) or grandparents ($\rho=0.741$, $P=0.057$). Regression analysis revealed a significant linear trend between IM Maximum and IM Index in the child group (IM Maximum $=1.60\times$ IM Index $+0.289$, $R^2=0.334$, $P=0.006$), but not for the parent (IM Maximum $=1.73\times$ IM Index $+1.38$, $R^2=0.024$, $P=0.550$) or the grandparent group (IM Maximum $=15.9\times$ IM Index -32.6, $R^2=0.284$, $P=0.126$). The regression model for the pooled data (displayed in Fig. 1) showed a significant linear trend (IM Maximum $=2.92\times$ IM Index -1.23, $R^2=0.205$, $P=0.002$).

3.1.2. IM Licence

Grandparents and adults reported similar IM Licences: all were allowed out in the neighbourhood on their own with minimal restrictions. The time limits put in place were either 'to be home for dinner' or 'by dark'. Of the child participants, 17 children (12 males and 5 female) were allowed in the neighbourhood on their own but experienced considerable restrictions around where they could or could not play. Six (28%) of the child participants were only allowed out for a set time between 30 min and 1 h and then were required to be home. Ten of the child participants were allowed out on their own if the location was prearranged and parents knew what time they would be home. Of the children that had access to a cell phone ($n=8$), they were all required to use these to keep in regular contact with their parents. One male child participant had complete freedom to go anywhere in the neighbourhood on their own and did not have any restrictions in regards to location of play or the amount of time they were out for. Four child participants (2 males and 2 females) were not allowed out on their own at all unless they were accompanied by either a sibling ($n=1$) or a friend ($n=3$). In addition, each of these children had to get prior approval from their parents as the length of time they would be out for, who they were going with and exactly where they were going. Due to the low numbers of participants who were not permitted to travel without adult supervision, meaningful comparisons between IM Licence and IM Index/IM Maximum were not possible.

3.2. Qualitative interviews

There were particular themes that emerged in response to key questions asked in the semi-structured interviews for each generation; relevant quotes have been included to emphasise these themes.

3.2.1. Grandparents

When asked if there were any reasons why they were not allowed to go to certain places either for themselves as 10–12 year olds or for their children (parent participants), none of the grandparent participants recalled any restrictions other than needing to be home by dinner.

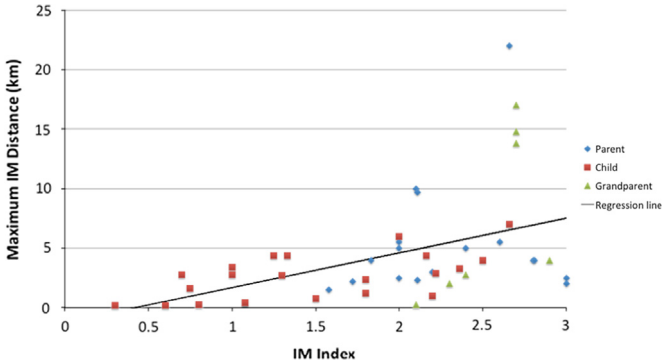

Fig. 1. Association between IM Maximum and IM Index for children, parents, and grandparent. The linear regression line was fitted to data from all three groups.

"*Just needed to be home in time for dinner, we just played in the street with other kids so did not need to travel far*" (Grandparent in response to their own childhood).

All grandparent participants noted drastic changes in the neighbourhood from when they were children to that of their grandchildren today. The significant rise in traffic volume, greater access to drugs, a decrease in neighbourhood sociability, and increased risk of stranger danger were all common changes mentioned. In addition, there was an overall view that children today are very sheltered or (to quote) 'mollycoddled'.

"*We used to have an open door all the time with people coming in – we never dreamed there would be a day where we would be locking the door with us inside!*" (Grandparent participant).

"*The biggest different today is that we do not know our neighbours – it took an earthquake for people to start talking to each other*" (Grandparent participant).

3.2.2. Parents

None of the parent participants could recall any reasons why they were restricted from certain places as a child other than needing to let their parents know generally where they were going and to be home by dark. In regards to perceived changes from when they were 10–12-year-old children, parents' responses were similar to the grandparents'. The changes most frequently discussed were an increase in traffic volume, speed that vehicles travel, threat of violence, and access to drugs. A decrease in neighbourhood sociability, a change in family structure with both parents working, and a rise in organised sport was also commonly mentioned.

In response to the question "are there any reasons why your child is not allowed to go out on their own or to certain places in the local neighbourhood?", 90% of parents brought up concerns of safety. When analysed for common themes, traffic (62%), stranger danger (47%), darkness (28%), and general safety (28%) were the most common reasons why parents do not allow their children out on their own.

"*Yes – (he is allowed out on his own) but everything must be prearranged, the route to school is prearranged and he has his cell phone. If he is not home by 4pm I worry*" (Parent of an 11 year old boy).

3.2.3. Children

All child participants were aware of the reasons their parents restricted them from going to certain places (safety, traffic, or strangers). However, 71% of the children had no concerns about travelling to certain places on their own. Of those that did have concerns, all responded with a fear of strangers, and two child participants mentioned a fear of traffic related accidents. The majority of children (76%) could identify places they would like to go to if they were allowed. The places most frequently mentioned were shopping malls, movies, and friends' houses. There were no significant gender differences.

"*My parents are concerned about my safety but I feel independent enough*" (male, 11-year old).

"*Mum knows I can look after myself but I guess roads are busy*" (female, 11-year old).

4. Discussion

Children's IM is a growing research field where by differences in measurement procedures and definitions of IM currently hinders further understanding. The primary purpose of this pilot study was to explore and compare three measures of children's IM across three generations. Each of the measures implemented (IM Licence, IM Maximum and IM Index) were feasible and acceptable for all participants to use irrespective of age and gender. The self-reported nature of the IM Licence and IM Index means the questions could be used as part of a larger survey or questionnaire, subsequently offering a low cost, quantifiable measure of children's independent mobility applicable for large sample sizes (Hillman et al., 1990; Shaw et al., 2013; Page et al., 2009).

However, as with previous studies, the complexity in conceptual definition of IM Licences has limited the comparability of IM Licence as a measure. The decision for parents and caregivers to grant IM Licences is rarely a 'yes' or 'no' decision. There are contingencies which affect their decision-making in certain circumstances (Mikkelsen and Christensen, 2009). This was apparent through the responses to IM Licence questions and the semi-structured interviews, whereby there was variation in the rules around the allowances given for children today including set time frames, companionship, pre-arranged locations and the use of a cell phone for ongoing parental contact. These data would support the need for a differentiated measure of children's IM which accounts for the extent in which children's independence can vary.

The IM Maximum utilised map drawing methodology similar to previous studies (Veitch et al., 2008; Freeman and Quigg, 2009) yet with a specific quantifiable variable. The mapping methodology provided an interactive experience for participants and the various functions of Google Maps, including the identification of key landmarks, zooming options and 'street view' perspectives, likely aided participants' recall. In addition, the data were easily interpretable, a limitation previously identified for static mapping techniques (Badland et al., 2011). While the estimates of IM Index and IM Maximum were significantly correlated, the proportion of explained variance (R_2) ranged from 2.4% (n.s) in parents to 33.4% in children. These findings suggest that to a certain extent these measures are conceptually related, i.e. the maximum roaming distance may directly influence choice of destinations and the frequency visited (or vice versa). However, there is a need for academic consensus on the definition and measurement of IM to facilitate comparability and accurate interpretation of future studies. It is our recommendation that the use of web-based interactive mapping offers the greatest potential to provide an accurate and in-depth measure of children's current IM distance, including possible inhibitors and enhancers of autonomous movement in the neighbourhood.

Our results also indicated substantial generational decreases in all measures of IM (IM Licence, IM Maximum and IM Index). Mean IM Index levels and mean IM Maximum decreased slightly (but non-significantly) between grandparents to parents, with relatively large decreases from parents to children. Only one child from today's generation was permitted the same unrestricted licence to roam and travel freely in the neighbourhood that their parents and grandparents experienced. These findings align with earlier research (Hillman et al., 1990; Shaw et al., 2013; O'Brien et al., 2000; Fyhri et al., 2011) that indicates children today experience much less freedom to play and explore their neighbourhood as their parents and grandparents did at the same age.

In regards to IM levels of children today, the findings of this study parallel current research. Children's mean IM Maximum was 2673 m (± 1929). Another New Zealand pilot study investigating the measurement of IM in 17 children aged between 5 and 12 found similar maximum roaming distances (Badland et al., 2011). It was also noted that some children had very low levels of IM; three children in this study had a maximum roaming distance of 250 m or less. In some instances children experienced severe restrictions on their play: for example, some children were required to have their outing prearranged at a designated location, or were confined to a 30 min time limit. Similar results were found in an Australian study of 212 children aged 8–12 years old, with 32% of the participants having an IM range less than 100 m, and 12% of all children not being allowed to walk or cycle without an adult (Veitch et al., 2008). Likewise, in a recent Canadian study of 856 children (10–12 years old), where parents were asked how often their child is allowed out without adult supervision (either on their own or with a friend), nearly 40% of the participants were never allowed out without an adult (Stone et al., 2014). While the long-term developmental effects of such low levels of IM are uncertain, there is emerging evidence to suggest that low IM may negatively impact children's physical and psycho-social development (Brockman et al., 2010; Page et al., 2009; Martínez-Gómez et al., 2011).

Previous research has reported consistent evidence that boys are granted more IM than females (Hillman et al., 1990; O'Brien et al., 2000; Tranter and Pawson, 2001; Kytta, 2004; Badland et al., 2011). It is understood that the reasoning behind this is twofold: that parents are more concerned with their daughter's safety, and that girls are encouraged to take up household responsibilities to a greater extent than boys (Valentine and McKendrick, 1997). While gender differences were apparent in parents and grandparents in the present study, there was little variation in the IM levels between genders in the child participants. It is possible that as children's IM levels drop to a very low level gender differences experienced previously will no longer be apparent. Indeed, one of the most recent studies in this area was unable to find differences in IM between boys and girls (Shaw et al., 2013).

The qualitative findings from this study demonstrate that for previous generations, parents had little or no concerns about their children roaming freely in the neighbourhood. By comparison, parents today expressed a number of concerns for their children's safety, especially in regards to traffic and 'stranger danger'. These fears have been well noted in previous literature as significant reasons why children's IM is restricted today (Foster et al., 2014; Tranter and Pawson, 2001; Carver et al., 2005; Prezza et al., 2001; Veitch et al., 2006). It is highly likely that parental concern for their child's safety and the change in neighbourhood sociability have resulted in children's IM Licences and independent roaming being more restricted. Conversely, children in this study did not share the same concerns regarding their safety as their parents. They expressed a desire to have more autonomous roaming and frustration at feeling capable to negotiate the neighbourhood safely while being heavily restricted from this. These findings are comparable to those from a study conducted in Australia (Tandy, 1999) and other another New Zealand study examining children's perspectives on their IM (Mitchell et al., 2007).

Given the exploratory nature of this pilot study and the small sample size, caution needs to be taken when making generalisations. In addition, the former home addresses of some of the grandparents had changed from a rural area to an urban area, and in some instances were difficult to locate exactly on Google Maps. It is possible this limited the recall ability for this generation. Finally, it was more difficult to recruit grandparent participants compared to child and parent participants due to unavailability, resulting in a proportionately lower sample size; this could potentially present sampling bias issues in future studies.

5. Conclusion

In conclusion, all measures of IM utilised in this pilot study were feasible and practical to use across three directly related generations. The suggested correlation between IM Index and IM Maximum is worth exploring further, especially the use of interactive mapping technology given the potential to accurately measure various important facets of children's IM. The findings that children's autonomous movement has declined significantly from earlier generations are concerning and further research is warranted to investigate possible associations with aspects of children's health.

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