Waterford Institute *of* Technology

INSTITIÚID TEICNEOLAÍOCHTA PHORT LÁIRGE

Gamification of physical activity and active travel in school-children; the impact of the Beat the Street intervention in Waterford, Ireland

A thesis submitted to Waterford Institute of Technology in fulfilment of the requirements for the Degree of Master of Arts

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Abstract

Introduction:
Levels of physical activity and active travel are insufficient in Ireland. Gamification may be an effective approach to increasing walking and cycling in school-children. Beat the Street is a real-life walking and cycling game where players accumulate points using swipe card technology. The primary purpose of this study was to measure the efficacy of the gamified intervention on travel modes in school-children.

Methods:
This study evaluates a seven-week (September-November, 2017) gamified intervention. A seasonally match repeat cross-sectional surveys were collected in 24 intervention schools (16 primary and 8 secondary) and 2 control primary schools. Baseline surveys were conducted in October 2016 in 5th & 6th years of primary schools and 1st year of secondary schools. Follow-up surveys were conducted in November 2017 in 5th & 6th years of primary schools and 1st year of secondary schools.

Results:
Overall, 1892 children completed self-report surveys at baseline (intervention 1769, control 123) and 1776 at follow-up (intervention 1674, control 102). Females were significantly ($p<0.001$) more likely to play the game regularly when compared to males. Almost 25.3% of all females played the game every day in contrast with 16.1% of males. A greater proportion of primary school-children played the game every week (66.1% vs 45.5% of secondary school-children). There was no overall change in the proportion of school-children who walked or cycled to school in the intervention schools (26.5% at baseline and 25.9% at follow-up in primary; 21.1% at baseline and 19.2% at follow-up in secondary) compared with control (45.4% at baseline and 43% at follow-up) post-intervention. Correspondingly, there was no overall change in the number of days school-children achieved 60 minutes of MVPA at follow-up in the intervention (5.5, ±1.72 days at baseline to 5.2, ±1.82 days at follow-up in primary; 4.8, ±1.88 at baseline to 4.5, ±1.90 in secondary schools) versus control schools (5.9, ±1.49 days at baseline to 5.5, ±1.85 days at follow-up in primary schools). Children recommended the game should have a greater number of boxes, a more comprehensive reward system and be more challenging, exciting and fun.

Discussion:
The BTS game was not effective in creating a modal shift to active travel to school. The game itself needs to employ a more persuasive architecture to maintain interest and participation levels. Despite this, the game achieved very high levels of unprompted awareness, particularly among primary school children and girls. Gamification of active travel to school should not be a stand-alone intervention. It should be integrated into multicomponent programs which include infrastructural provision, policy development and curricular programming.

Declaration

I hereby declare that this submission is my own work and that it contains no material previously published or written by another person, nor material which has been accepted for an award in any other university or institute of higher learning, except where due acknowledgement has been made in the text.

Signed: _____Date:_____

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List of Abbreviations

AT	Active Travel
ATS	Active Travel to School
AVG	Active Video Game
BMI	Body Mass Index
BTS	Beat the Street
CI	Confidence Interval
CHBR	Centre for Health Behaviour Research
CSPPA	Children's Sport Participation and Physical Activity
CVD	Cardiovascular Disease
IRR	Incidence Rate Ratio
LSP	Local Sports Partnership
MET	Metabolic Equivalent of Task
NPAP	National Physical Activity Plan
OR	Odds Ratio
PA	Physical Activity
PE	Physical Education
RCT	Randomised Controlled Trials
RFID	Radio Frequency Identification
SB	Sedentary Behaviour
SES	Socioeconomic Status
SR2S	Safe Routes to School
STA	Smarter Travel Area
STC	Smarter Travel Campus
STW	Smarter Travel Workplace
WCCC	Waterford City and County Council
WHO	World Health Organization
WIT	Waterford Institute of Technology

1 Introduction

1.1 Physical Inactivity and Active Travel

In children, meeting the recommended 60 minutes of moderate to vigorous physical activity (MVPA) a day throughout the week, provides significant physical (lower adiposity, improved muscular strength and bone health), psychosocial (improved self-perception and self-esteem), and cognitive health benefits (World Health Organization, WHO, 2011; Poitras et al., 2016; Dale, Vanderloo, Moore & Faulkner, 2018; Lubans et al., 2016). However, the majority of children do not get sufficient physical activity (PA). The most recent data on the global prevalence of insufficient PA showed that 81% of children (11-17 years of age) do not meet the WHO recommendations on PA for health (WHO, 2018). This indicates that only 19% of the population of children globally, spend an hour a day being physically active (WHO, 2018).

Similarly, in Ireland, 81% and 88% of primary and secondary school-children, respectively, does not meet PA recommendations (Woods, Tannehill, Quinlan, Moyna & Walsh, 2010). One factor that contributes to these statistics is our dependency on the car as the main mode of travel in Ireland. The car is the primary mode of travel to school, college, or work for 66% of the Irish population (Central Statistics Office, CSO, 2017). In Waterford City and suburbs, active means of travel were only used by 15.2% of all commuting to work (CSO, 2017). Likewise, over 70% of work trips were made by a car (CSO, 2017). Between 1990 and 2013, the number of private cars increased by 140%, making it the largest growing economic sector in Ireland (SEAI, 2014). This also contributed to an increase in CO^2 production, whereby the transport sector now accounts for one-fifth of all CO^2 emissions in Ireland (European Commission, 2015). The promotion of walking and cycling for transport can be an effective way of incorporating PA into daily living while simultaneously reducing the modal split for motorised modes of travel and CO^2 emissions (Larouche et al., 2014; Sahlqvist, Song & Ogilvie, 2012).

1.2 Active Travel Policies and Programmes in Ireland

In recent years, Ireland has developed policies and action plans to protect the environment, promote sustainable travel and increase PA levels across the population. The government established a Sustainable Transport Division, in the Department of Transport, Tourism, and Sport in 2009. Since then, the division published a sustainable travel (Smarter Travel) policy (Department of Transport, 2009a), and the National Cycle Policy Framework (Department of Transport, 2009b). Both documents outline strategies for achieving a modal shift to more sustainable travel in Ireland. The primary aim of the division was to reduce car dependency, improve the public transport network and increase the accessibility of sustainable modes of transport (Department of Transport, 2009a; 2009b). In 2013, Framework for Improved Health and Wellbeing (2013-2025) was launched by Healthy Ireland (Department of Health, 2013). The Healthy Ireland Framework was based on existing policies and proposed measures to ensure effective cooperation and collaboration between several sectors in Ireland to implement new evidence-based policies. Subsequently, the National Physical Activity Plan (NPAP) was published in 2016 (Department of Health, 2016). The NPAP contains several actions related to the promotion of walking and cycling for transport among school-children, and particularly in relation to the school commute.

To date, there has been a limited number of interventions targeting active travel (AT) in school-children. Local Sports Partnerships (LSP) play an important role in supporting the implementation of AT programmes in schools in Ireland. These include; cycling skills training, AT challenges and walk or cycle to school days. An Taisce co-ordinate the Green Schools Programme where participating schools are awarded a travel flag for promoting the use of sustainable modes of travel to school. Despite this, the promotion of active travel to school (ATS) in Ireland is limited compared with less car-oriented countries and the evidence for the effectiveness of existing AT interventions is weak (The Institute of Public Health in Ireland, 2011; Gannon, 2018). Recently, the concept of gamification has been suggested as a strategy for behaviour change in both adults and children. Gamification can be explained as ‘the use of game design elements in a non-game context’, in this situation in health promotion setting (Deterding, Dixon, Khaled & Nacke, 2011, p.9).

1.3 The Beat the Street Project

'Beat the Street' (BTS) is a real-life walking and cycling game for entire communities, delivered internationally by a company called Intelligent Health Ltd (UK). Intelligent Health Ltd. develops and organises different walking and cycling interventions. It primarily serves communities, primary care providers, schools, sports entities, and businesses in different countries. The company was founded in 2006 and is based in Reading, United Kingdom (Company overview for Intelligent Health Limited., n.d.). The Beat the Street project is a gamified intervention that aims to connect individuals with their local environment and supports long-term behaviour change by creating a social norm around becoming active. Participants of the project can register and play the game for free by collecting points on a radio frequency identification (RFID) card of fob key by tapping the RFID readers called 'beat boxes' (see figure 1.1 and 1.2 below). During the game, beat boxes are mostly attached to lamp posts and are spread approximately half a mile apart at strategic locations around a community. To date, there have been 810,710 BTS players worldwide. In 2016 alone, 300,000 people played the game across 21 different game locations (Intelligent Health, n.d.).

Each card and fob are numbered; thus, when it is being tapped on the beat box, it sends the location information to a database. If a participant of the project taps the card/fob on two boxes within an hour (at least 1-minute time gap between taps), that participant receives 10 points. If there is more than one hour between taps, then the next beat box tapped acts as a 'start' point, and the process begins again. Participants compete against other teams by collecting as many points as possible. Participants can follow their progress on the BTS website. The website shows which beat boxes they tapped, the number of points they collected and the distance they travelled (in miles). The website also contains information about the total/average number of points collected by individuals and teams as well as leader boards. A big part of the game is an extensive social media campaign run by the local BTS coordinators from Intelligent Health Ltd. The BTS coordinators use Facebook and share photos, competitions, and videos daily. They raise the profile of the BTS partners and encourage players to share positive stories about how to play BTS and engage other people within the community.

Figure 1.1.BTS RFID card and fob key

Figure 1.2.BTS RFID readers called beat boxes

1.4 Study Context and Rationale

In 2017, Intelligent Health Ltd. was commissioned to implement BTS for the very first time in Ireland. The seven-week project in Waterford took place in Waterford City, Kilmacthomas, and Dungarvan. At this point, Sport Ireland commissioned WIT's Centre for Health Behaviour Research (CHBR) to measure the impact of the BTS project on active travel in school-children. In 2016, the CHBR had conducted an audit of active travel and physical activity behaviour in school-children in Waterford City. This allowed for a repeated measures design but limited the data to Waterford City only. Therefore the data presented in this dissertation relates to the school-children from Waterford City only and not Kilmacthomas or Dungarvan. Further details on the BTS intervention are discussed in the methodology section.

The primary focus on active travel was agreed upon based on discussions with Intelligent Health Ltd. in terms of the times when the game was played most frequently. The previous sections have established that Ireland is a very car-dependent country with low levels of active travel among school-children. Only a minority of school-children walk or cycle to school in Waterford City. Creating a modal shift to active modes of travel is important because it presents an opportunity to increase the total PA in school-children. There have been very few robust and independent evaluations of gamified PA interventions. Indeed, internationally, there is a paucity of community-wide active travel interventions targeting school-children and particularly in car-oriented countries. While Beat the Street is designed as a community-wide physical activity intervention, it's greatest potential may lie in the active travel domain and specifically among school-children. For these reasons, active travel was the primary focus of the study but physical activity was also measured.

1.5 Aims and Research Questions

The primary aim of this study was to examine the extent to which BTS can create a modal shift to active travel among school-children.

The specific research questions are as follows:

1) What were the characteristics of the sample?
2) Who played BTS and how frequently did they do so?
3) How aware were school-children of BTS?
4) What impact did BTS have on active travel to school?
5) What impact did BTS have on PA in school-children?
6) What are the factors that influence active to school among school-children?
7) What did school-children perceive to be the strengths and weakness BTS?

2 Literature review

The primary aim of this study was to examine the potential of BTS to create a modal shift from passive to active modes of travel to school. It is very likely that such an outcome would increase overall levels of physical activity in children. Therefore the following chapter examines the contribution that activity travel makes to total physical activity, and it includes a comprehensive analysis of the factors that influence children's travel behaviour using an ecological framework. This was done to highlight the complexity of travel mode choices and also the difficulty in shifting travel behaviours in car-oriented countries. The chapter then discusses the impact of several other gamified interventions on the physical activity before focussing of recent evaluations of BTS. The critical components of successful gamified interventions are also discussed.

2.1 The Prevalence of Active Travel

According to the Central Statistics Office (CSO), the number of overall commuters to work, school and college have continued to rise since the first recorded census in 1986 (CSO, 2017). The number of commuters reached nearly 3 million in April 2016 (2,962,550), showing an increase of 9.3% since the 2011 census (≈2,7 million) and a 62% increase since 1986 (≈1.8 million). Correspondingly, car ownership and car dependency as a mode of transport continued its upward trend. To clarify, the number of households in 2016, having at least one car was 1.39 million, which is 30,063 more than in 2011 (1.36 million; CSO 2017). The car has remained the primary mode of travel to school, college or work for 66% of the Irish population (CSO, 2017).

2.1.1 Primary school-children

In relation to primary school-children, the data indicates that the proportion of children walking or cycling to school continues to drop over time and is substantially outweighed by those travelling by car (see figure 2.1; CSO, 2017). The number of primary school-children actively commuting to school decreased from 49.5% in 1986 to 25% in 2016. Simultaneously, car usage increased from 24% to 59.8% during the same period (CSO, 2017). These

trends are supported by other Irish studies. Data from the ‘Growing up in Ireland’ study of nine-year-olds (Williams et al., 2009), showed that 60% of children travelled to school by car while only 26% chose active modes of travel (25% walked, 1% cycled). The data from the ‘Children’s Independent Mobility on the Island of Ireland’ study (O’Keefe & O’Beirne, 2015), were also comparable, with 24.6% of primary school-children choosing active modes of travel to school (22.1% walk, 2.5% cycle). However, it is important to understand that the proportion of primary school-children who were granted independent mobility (freedom to travel to school without adult supervision) was even lower. Approximately 90% of all trips to school were made in the company of adults (O’Keefe & O’Beirne, 2015).

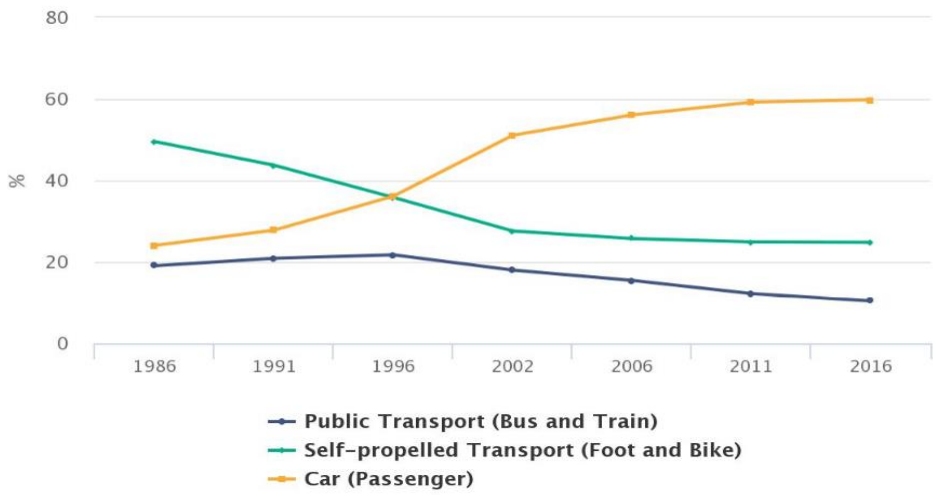

Figure 2.1. Modes of travel for primary school-children, 1986-2016 (CSO, 2017)

2.1.2 Secondary school-children

The trends in ATS in secondary school-children are similar. The number of active commuters dropped from 49% in 1986 to 23.3% in 2016 (see figure 2.2; CSO, 2017). In the same period, the number of children driving or being driven by car to school increased from 11% to 42% (CSO, 2017). From 1986 to 2011, the proportion of secondary school-children cycling to school decreased by 87% (from 15.3% to 2%). The last recorded census showed that the number of children travelling to school by car increased by 16% from 2011 to 2016 (CSO, 2017). The proportion of children who walked to school

in 2016 decreased by almost 8% since 2011 (from 23% to 21.2%; CSO, 2017). However, the 2016 census saw a reversal of this trend with a 10.5% increase in cyclists since 2011 and notably the majority of cyclists (over 90%) were male. Despite this, the number of female cyclists has also increased by over 30% since 2011 (CSO, 2017).

These trends are supported by other Irish studies. The data from the 'Children's Sport Participation and Physical Activity Study' (CSPPA) shows that only 37% of the secondary school-children walk to school and only 3% cycle (Woods et al., 2009). However, the figures for independent walking and cycling to school are even lower. O'Keefe and O'Beirne (2015) reported that only 12.6% and 1.2% of secondary school-children walk or cycle to school independently.

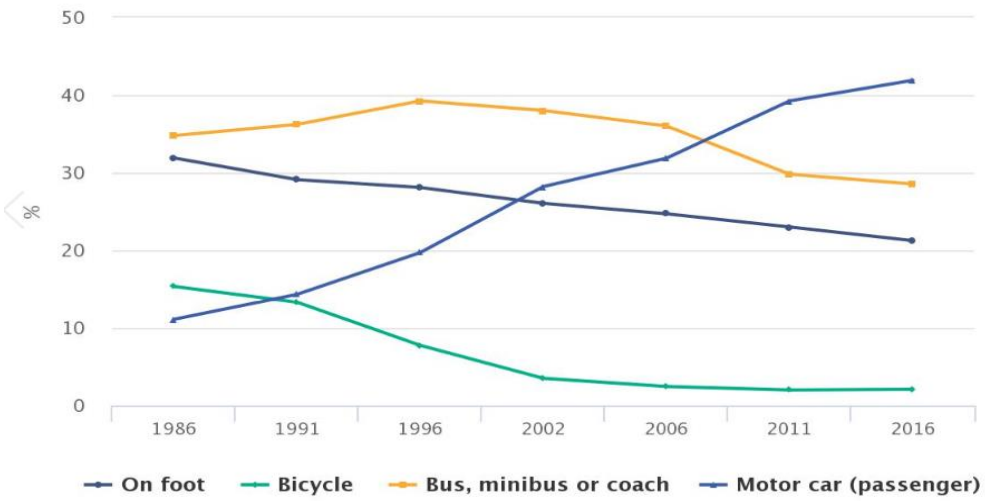

Figure 2.2. Modes of travel for secondary school-children, 1986-2016 (CSO, 2017)

2.2 The Contribution of Active Travel to Physical Activity Recommendations

The National Guidelines on Physical Activity for Ireland (Department of Health and Children & Health Service Executive, 2009) in line with the WHO's global recommendations (WHO, 2011), state that children and adolescents (aged 2-18) should be active at a moderate-to-vigorous level for at least 60 minutes a day. Despite these recommendations, the available data shows that Irish children were assigned a D grade for overall PA in the latest Global Matrix of Report Card Grades (Research Work Group, 2016). Physical activity levels

are typically higher in younger children, in males, and children from higher social classes (Murphy, Rowe & Woods, 2016; Gavin et al., 2015). The CSSPA-Plus study reports that only 9% of primary and 4% of secondary level children meet the PA recommendations (Murphy, Rowe & Woods, 2016). The problem was found to be particularly pronounced in females. In primary schools, only 7.3% of females and 10.6% of males meet the recommendations of 60 mins of MVPA a day. In secondary schools, only 3.1% of females and 5.6% of males reach these guidelines (Murphy, Rowe & Woods, 2016).

There is a considerable amount of data to support the assertion that children who actively commute to school have higher levels of PA than those who use passive modes of travel to school (Larouche et al., 2014; Doorley, Pakrashi & Ghosh, 2015; Kelly et al. 2014; Mueller et al. 2015; Voss, 2018; O'Keefe & O'Beirne, 2015). Children who cycled or walked to school accumulated more minutes of daily PA and spend more time in MVPA (up to 45 minutes a day; Larouche et al., 2014). Voss (2018), in his review, states that walking to school can provide an additional 17 minutes of MVPA per day for primary school-children and 14 minutes for secondary school-children (approximately 23% and 36% of the total daily PA). For that reason, ATS may be a helpful way of increasing PA levels among children. What is more, research indicates that children who actively commute to school accumulate a higher volume of steps per day as well as greater overall energy expenditure, compared to those who commute by passive means (Larouche et al. 2014). Further evidence suggests that there is a dose-response relationship between ATS and PA. Children who actively travel to school are more physically active outside school hours than children who were driven to school (Larouche et al. 2014; Voss 2018).

2.3 Benefits of Physical Activity and Active Travel for Children

The evidence for the health benefits of PA is unequivocal. The data from a recent systematic review indicated that PA is inversely associated with lower risk of all-cause mortality and with at least 25 chronic medical conditions such as cardiovascular disease (CVD), type 2 diabetes, hypertension, breast cancer, colon cancer, gestational diabetes, gallstone disease, ischemic heart disease, and ischemic stroke (Warburtonn & Bredin, 2017). The authors state that people of any age can benefit from being active and that there are no minimum thresholds for obtaining these benefits. Also, PA was found to increase overall life expectancy and improve self-perceived health status in adolescents (Warburtonn & Bredin, 2017). Poitras et al., (2016), in their review, looked at the benefits of PA-specific to school-aged children and adolescents. According to the authors, children's physical, psychosocial, and cognitive health can benefit from any pattern of PA (sporadic, bouts, continuous). Across 162 studies from 31 countries, there was consistent evidence of favourable relationships between PA and adiposity. Children who had more PA had lower adiposity than less-active children and had lower odds of being overweight or obese. Furthermore, PA was found to improve several cardiometabolic biomarkers (cholesterol, BP, triglycerides, insulin resistance and fasting insulin, and fasting glucose) as well as improving physical fitness (aerobic fitness, muscular strength, and endurance), and bone health (Poitras et al., 2016).

There was also a positive association between total PA and quality of life/well-being, motor skill development, and an inverse association with psychological distress in children (Donnelly et al., 2016; Archer, 2014; Dale, Vanderloo, Moore & Faulkner, 2018). Other reviews examined the mental benefits of PA (Lubans et al., 2016; Dale, Vanderloo, Moore & Faulkner, 2018). These reviews have demonstrated that PA contributes to the reduction of depression/depressive symptoms in children and youth. Likewise, it contributes to improved physical self-perception and self-esteem (Dale, Vanderloo, Moore & Faulkner, 2018; Lubans et al., 2016). Finally, Donnelly et al., (2016) showed that PA positively improves brain function and cognition in

children (attention, information processing, tasks execution, memory) and ultimately aid their academic performance.

There is consistent evidence to show that the switch to AT, results in better air quality, reduced traffic, reduced CO^2 emissions and decreased noise caused by road transport (Giles-Corti et al., 2010; Nazelle et al., 2011; Haines, 2017). In addition to the economic and environmental benefits, there is also evidence indicating that AT can have broader social and psychosocial health implications for children (Voss, 2018). As mentioned earlier, children who walk or cycle to school have lower odds of experiencing depression and psychological distress. Likewise, children who choose AT over passive travel have higher levels of happiness and overall psychological well-being (Voss, 2018). Children themselves perceive ATS as an opportunity for spending more time with parents and friends (Inchley & Cuthbert, 2007; Voss, 2018). This perception, in turn, may have a beneficial effect on mental health and well-being in children (Voss, 2018). Equally, parents feel that cycling can help their children develop a sense of freedom, independence, and improve their road awareness (Hearth Foundation, 2012; Living Streets, 2008). The evidence from several systematic reviews suggests that there is a consistent and robust relationship between cardiorespiratory fitness, cardiorespiratory health, and ATS (Davison, Werder & Lawson, 200; Xu, Wen & Rissel, 2013; Kelly et al., 2014; Larouche et al., 2014). Children who walked, and especially those who cycled to school, had greater cardiorespiratory fitness and thus lower risks of CVD (Davison, Werder & Lawson, 2008; Larouche et al., 2014; Xu, Wen & Rissel, 2013; Voss 2018). Some studies have also looked at the association between ATS and body mass index (BMI), body composition, and waist circumference measurements (Faulkner et al., 2009; Lubans, Boreham, Kelly & Foster, 2011; Larouche et al., 2014; Voss, 2018). The evidence here, however, is inconclusive.

2.4 The Factors that Influence Physical Activity and Active Travel in Children

Ecological models provide the most comprehensive way of showing interrelations between individuals and their social and physical environments (Bauman et al., 2012). Factors on an individual, social, and environmental spectrum act independently or together and influence whether or not children use ATS and reach their recommended PA. These factors have the potential to promote or restrict these behaviours and are influenced by the perceptions of parents or caregivers and thus are unique to each child's physical and social environments. The primary correlates of PA and AT in children are presented below.

2.4.1 Physical activity

The evidence from systematic reviews regarding the correlates of PA shows that the majority of research is cross-sectional and originates from the USA and Canada (Sterdt, Liersch & Walter, 2013; Tonge, Jones & Okely, 2016; Martins, Marques, Peralta, Palmeira & Carreiro da Costa, 2017). The main correlates of PA have been consistent across the literature. Compared with their inactive peers, active children are more likely to be male, younger, white, have higher self-efficacy, more support from family and significant others, live in walkable environments, and have greater access to sport/recreational facilities, and programs (Sterdt, Liersch & Walter, 2013; Tonge, Jones & Okely, 2016; Martins et al., 2017; Bauman et al., 2012). Martins et al., (2017) in their review of reviews, found that children who spent more time outside and were in schools with PA conducive policies (i.e. time available for incidental PA and play school trips) are more likely to be physically active. Finally, neighbourhood crime and traffic speed/volume were negatively associated with time spent being PA.

2.4.2 Active travel

With regard to AT, most of the evidence is also cross-sectional and originates mainly from the USA, Australia, and Europe (Lu et al., 2014; Pont, Ziviani, Wadley, Bennett, & Abbott, 2009; Wong, Faulkner, & Buliung, 2011; Bauman et al., 2012). This is problematic because there are different land use patterns in the USA compared with, for instance, European countries (Kemperman & Timmermans, 2012). For that reason, the results may be region or country-specific only and cannot be generalised directly to other countries. The correlates of AT presented below are explained at individual, social, and physical environmental levels.

2.4.2.1 Individual level

A recent systematic review of ATS in children in North America stated that individual factors in the ecological framework are usually weakly or moderately associated with ATS (Rothman et al. 2017). According to Rothman et al. (2017), gender was found to be weakly associated with ATS with 36% of studies reporting that males engage in ATS more often than females (Rothman et al. 2017). This is consistent with previous research by Bauman et al., (2012), who stated that ‘’sex is a correlate but not a consistent determinant’’ of ATS in school-children (p.260). A recent systematic review indicates that gender differences in children’s independent mobility are inconsistent and equivocal (Marzi & Reimers, 2018). It is worth noting that some research shows that males tend to cycle to school more often than females (Merom, Tudor-Locke, Bauman and Rissel, 2006; Garrard, 2009, Emond & Handy, 2012), while females walk to school more often than males (Leslie, Kremer, Toumbourou & Williams, 2010). According to Carev et al., (2005), significantly more children cycle for recreational/leisure reasons than for transport. A number of studies have reported lower level of ATS in young females compared to males, which may be explained by their lower levels of independent mobility which will be discussed later in this chapter (Brown, Mackett, Gong, Kitazawa & Paskins, 2008; Foster, Villanueva, Wood, Christian & Giles-Corti, 2014; O’Keefe & O’Beirne, 2015; Mah et al., 2017).

According to Rothman et al., (2017), age is an individual level factor which is often found to be associated with ATS. Most studies report that ATS is more common in younger children. Indeed, this was borne out in the Irish CSO data outlined earlier in this chapter. Bringolf-Isler et al., (2008) found that in Switzerland, active commuting was more prevalent among nine and ten-year-olds than it was among younger children (6-7 years) and older children (13-14 years). This trend is supported by Pabayo, Gauvin, and Barnett (2011), who found that ATS continued to decline throughout the adolescent years in Canadian youth. Correspondingly, Emond and Handy (2012), found that cycling decreases with age. As older adolescents obtain their driving licence, the proportion of young people cycling drops from nearly 50% to 25%. Longitudinal studies from Canada (Pabayo, Gauvin & Barnett, 2011) and the UK (Panter, Corder, Griffin, Jones, & van Sluijs, 2013) have shown that lower household income is associated with more frequent ATS in children of all ages. Likewise, car ownership has been shown to be associated with AT in children. According to Larouche, Faulkner, and Tremblay (2013), children were as much as five times less likely to walk or cycle to school if their parents owned at least two cars. Several systematic reviews confirmed that lower socioeconomic status (SES), single-parent households and lack of car ownership are positive correlates of AT in children (Davison, Werder and Lawson, 2008; Pont et al., 2009; Bauman et al., 2012). Likewise, children, self-reported racial identity, was moderately associated with ATS (Rothman et al. 2017). According to Rothman et al. (2017), in studies conducted in the US, the Asian race was adversely associated with AT, whereas Hispanic race was most positively associated with walking and cycling to school. Recent Irish data showed that 38% of non-Irish children in Ireland walked to school compared with 22.6% of Irish children (CSO, 2017).

2.4.2.2 Social environment level

The social environment in this section relates to the influence of family, friends, social circles and the community on children's mode of travel. A recent systematic review explains the complexity of factors that underpin the parental decisions relating to their children's AT and independent mobility

(Egli, Ikeda, Stewart & Smith, 2018). Parents were described as ‘gatekeepers’ to their offspring’s AT because of current socially validated norms and the convenience of doing so (Egli et al., 2018). The prevailing norm of being a ‘good parent’, thus a ‘good mother’ (Dowling, 2000), is commonly comprehended as driving children around, rather than letting them travel autonomously (Egli et al., 2018). Likewise, a parent may act as a role model for their children. Research indicates that children are more likely to actively commute to school when their parents walk or cycle themselves (Henne, Tandon, Frank, & Saelens, 2014; Panter, Jones, et al., 2013).

A ‘good parent’ is perceived to be someone that provides their children with the opportunity to study in a ‘better’ out-of-zone school and letting them try out-of-school activities that ultimately limits their opportunities for independent AT from place to place (Witten, Kearns, Carroll, Asiasiga & Tavae, 2013). Likewise, a culture of car use and the perception of cars as being more convenient than walking and cycling results in lower levels of the latter modes of transport (Lorenc, Brunton, Oliver, Oliver & Oakley, 2008). Additionally, modern-day parents face multiple demands on a day-to-day basis. Between work, dropping children to schools and after-school activities, shopping and much more, ‘trip chaining’ makes driving a more convenient and time-saving solution (Dowling, 2000, Witten et al., 2013; Egli et al., 2018).

As mentioned in the previous paragraph, independent mobility given by parents is another correlate of ATS in children. Research indicates that children are typically given independent mobility between the ages of 8-13 years and those with higher levels of independent mobility, tend to walk or cycle to school more often than children with restricted independent mobility (Carver et al., 2014; O’Keefe & O’Beirne, 2015; Schoeppe, Duncan, Badland, Oliver, & Browne, 2014; Foster, Villanueva, Wood, Christian & Giles-Corti, 2014; Egli et al., 2018). In general, females were found to be less likely to ATS than males. This may be partly explained by their lower levels of independent mobility (Brown, Mackett, Gong, Kitazawa and Paskins, 2008; Ducheyne et al., 2012; Foster, Villanueva, Wood, Christian & Giles-Corti, 2014). This is potentially due to parental perceptions of neighbourhood safety and their concerns about letting a female travel home alone (Foster et al., 2014; Brown et al., 2008; Villanueva et al., 2013). Additionally, children of

parents who have lower safety concerns, use AT more often than their counterparts (Egli et al., 2018). Marzi and Reimers (2018) state that in countries with the highest levels of independent mobility, such as Finland, Germany, Norway, Sweden, Japan, and Denmark, there were no significant gender differences found in granting the licence of independent travel (Shaw et al., 2015). According to Shaw et al., (2015), there are no significant gender differences in independent mobility in Ireland, although Ireland was ranked 12th of 16 countries in terms of not granting early independent mobility. However, conflicting results were reported by O'Keefe and O'Beirne (2015), who found gender to be an important correlate of independent mobility. According to the authors, there are six principal licences of independent mobility, and according to their findings, a higher proportion of males than females were able to secure five of the six licences of independent mobility. Additionally, males could attain parental permission to travel independently earlier than females (see table 2.1). The reason for the variance in levels of independent mobility across different countries may be explained by differences in traffic congestion, speed law enforcement, the nature of road design or having national policies promoting AT (Shaw et al., 2015).

Table 2.1. Mean age at which parents state they are likely to confer mobility licences on their children
O'Keefe & O'Beirne (2015)

Girls	Indicator of Mobility	Boys
9.67	Age at which the child was permitted to cross the road	9.41
10.47	Age at which the child was permitted to cycle on main roads alone	10.64
9.79	Age at which the child was permitted to travel on local buses alone[16]	7.49
13.50	Age at which parents expect to confer on their child the licence to cycle on main roads alone	13.27

Parental support of walking and cycling is significantly associated with children's ATS, irrespective of other factors such as; age, sex, distance to school, and perceptions of pedestrian/traffic and crime safety (Mah et al., 2017). Children who obtain more support and encouragement from parents were found to be more likely to always cycle to school, and less likely to never cycle to school (Ducheyne et al., 2012). Also, the quality and strength of

connections that children have within the neighbourhood and people living nearby appear to be linked with parental perception of safety (Egli et al., 2018). It appears that a greater number of children within the immediate area, a stronger social network with neighbours, and the resulting informal social control, results in lower parental fear of the unknown. This, in turn, increases the likelihood of children engaging in AT (Egli et al., 2018). Data from cross-sectional 'SPEEDY' study in England showed that children who reported having peer encouragement were as much four times more likely to cycle as a means of travel, rather than use motorised transport (Panter, Jones, Sluijs & Griffin, 2009). Correspondingly, a qualitative study of older adolescents (mean age of 17 ± 1.2 years), showed that adolescents prefer to cycle with friends and are more likely to cycle longer distances when accompanied (Simons et al., 2013).

2.4.2.3 Physical environmental level

Evidence suggests that the most influential physical environmental correlates of ATS in school-children are; the proximity of home to school, built environment characteristics, neighbourhood walkability, safety, and the type of living area (rural vs urban, Davison, Werder and Lawson, 2008; Wong, Faulkner & Buliung, 2011; Larouche, 2015; Rothman et al., 2017). In Ireland, proximity to school was recognised as the most important correlate of AT in school-children (Woods, Tannehill, Quinlan, Moyna & Walsh, 2010; Daniels et al., 2014). According to Williams et al., (2009), in Ireland, primary school-children living greater than 1.5 miles from their school were twice as likely to use passive modes of travel to school compared with children living within a 0.5-mile radius of their schools. Among Irish adolescents (15-17 year-olds), the threshold distances for walking and cycling to school were found to be 1.5 and 2.5 miles, respectively (Nelson, Foley, Ogorman, Moyna & Woods, 2008). Similarly, data from the UK SPEEDY study (Chillón, Panter, Corder, Jones, & Van Sluijs, 2015) showed that children living closer to school (<1-mile radius) were approximately twice as likely to walk to school than those living further away (>1.5 miles). This is consistent with findings from Canada,

US, and Europe (Mitra, Papaioannou & Habib, 2015; Emond & Handy, 2012; Kemperman & Timmermans, 2012; Ducheyne et al., 2012; Garnham-Lee, Falconer, Sherar & Taylor, 2016). Research suggests that the threshold distances for ATS are likely to increase as children get older (Chillón et al., 2015).

Attributes of the built environment were found to be another correlate of AT in school-children. Davison, Werder, and Lawson (2008) stated that a greater proportion of children walk or cycle to school when road and footpath infrastructure is present, i.e. controlled intersections, a direct route to school or a small number of hills. In the California Safe Routes to School (SR2S) programme, Boarnet et al., (2005) found that 15.4% of children living in more pedestrian-friendly areas (presence of footpaths, traffic lights, improved pedestrian crossings, and bicycle paths) walked to school compared with 4.3% of those who lived in less pedestrian-friendly areas.

Christiansen et al. (2014) found that in Denmark, walkability[1] is positively associated with ATS. In schools with a high walkability index, as much as 90% of all trips were made by active transport. In schools with a low walkability index, 76.6% of trips were made by AT. In the Netherlands, a higher proportion of children engage in AT in neighbourhoods that have more recreation areas, better infrastructure, and are densely populated (Kemperman & Timmermans, 2012). Data from the Dutch 'SPACE' study (Vries, Hopman-Rock, Bakker, Hirasing & Mechelen, 2010) showed that a greater number of pedestrian crossings and parallel parking spaces in the neighbourhood were positively associated with walking and cycling trips for transport. They also stated that the correlates of AT-related to the built environment were likely to change depending on the purpose of travel (e.g. destination) and mode of travel (walking or cycling). For example, walking for transport to any destination was correlated with the number of cycle lanes, traffic lights, and roundabouts in the neighbourhood. On the other hand, cycling for transport to any destination was correlated with the number of recreation facilities, traffic safety, footpaths, pedestrian crossings, traffic

[1] Walkability is a combined measure of residential density, land use mixture, and the connectedness of streets (Owen et al., 2010)

lights, and parking spaces in the neighbourhood. Walking to school was associated with the presence of green space, pedestrian crossings, parking spaces, and roundabouts in the neighbourhood. In contrast, cycling to school was associated with the number of recreational facilities, the presence of green space, pedestrian crossings, traffic lights, and parking spaces in the neighbourhood.

Walkability is also an important correlate in countries with lower levels of AT. An observational study in Toronto found that the presence of pedestrian crossovers (Incidence Rate Ratio (IRR) 1.32), traffic lights (IRR 1.19), and intersections (IRR 1.03) were positively associated with walking to school (Rothman, Buliung, Macarthur & Howard, 2014). Additionally, it was found that the presence of crossing guards was positively associated with walking to school (IRR 1.14; Rothman, Buliung, Macarthur & Howard, 2014). Similar findings were reported in Ireland. Among Irish children, the primary correlates of ATS were the presence of footpaths and wider footpaths (Daniels et al., 2014) as well as well-lit streets, land use mix diversity, access to shops, access to public transport, the presence of public parks, and bike lanes (Nelson & Woods, 2010).

Finally, it has been shown that children living in urban areas tend to walk and cycle more often than those living in rural areas (Davison, Werder & Lawson, 2008; Daniels et al., 2014; CSO, 2017). The most recent census data in Ireland (CSO, 2017) shows that almost half of secondary school-children from rural areas, travelled to school by car, compared with 37.4% of children from urban areas (CSO, 2017). Correspondingly, walking rates were higher in urban regions where more than 33% of students walked to school compared with only 4.3% in rural areas. These differences may be somewhat explained by greater walkability and, to a lesser extent, congestion in urban areas.

2.5 Physical Activity and Active Travel Interventions

2.5.1 Physical activity

According to Heath et al., (2012), up until three decades ago, the main focus of health care organisations, was to ‘’monitor, protect and promote public health’’ (p.272). Current knowledge and experience allowed for an expansion of this focus to include initiatives aiming to prevent and control injuries and chronic diseases, and interventions promoting positive behaviours. In recent years, the methods of health promotion have evolved from community-based interventions that utilised an informational and behavioural-based approach to also include a focus on settings, the environment, and policy-based interventions (Heath et al., 2012). Hunter et al. (2015) reviewed twelve PA intervention studies that included policy and physical environmental components. They concluded that interventions that included these components were more likely to produce substantial changes in PA behaviour. The ‘Play Street’ intervention in Belgium is one example of such an intervention. The intervention involved closing a street to motorised traffic during a holiday period for children to play safely without traffic. The results showed that the creation of a safe play space near a child’s home might be an effective way of increasing MVPA time and ultimately decreasing their sedentary time (D’Haese, Dyck, Bourdeaudhuij, Deforche & Cardon, 2015). Several systematic reviews of PA interventions targeting school-children have concluded that multicomponent, multisector, and multisite interventions produce the most substantial results (Verjans-Janssen, Kolk, Kann, Kremers & Gerards, 2018; Erwin, Beighle, Carson & Castelli, 2013; Heath et al., 2012; Meester, Lenthe, Spittaels, Lien & Bourdeaudhuij, 2009). Interventions that involve direct parental involvement, peer support, and provide comprehensive school-based PA programmes (i.e. education, improved physical education (PE) classes, environmental and policy changes) may provide the most effective and sustainable behaviour changes (Bourdeaudhuij et al., 2011; Meester et al., 2009). It is important to note that the best interventions offer gender-specific programmes that cater for the unique needs of young females and focus on one specific behaviour change at a time (Biddle, Braithwaite & Pearson, 2014; Camacho-Minano, Lavoi & Barr-Anderson, 2011; Meester et

al., 2009). Nevertheless, the evidence shows that PA interventions have only a small-to-modest effect on children's overall activity levels (Camacho-Minano, Lavoi & Barr-Anderson, 2011; Metcalf, Henley & Wilkin, 2012; Nooijen, Galanti, Engström, Möller & Forsell, 2017).

2.5.2 Active travel

Interventions promoting ATS employ similar approaches as interventions promoting PA. The majority of AT interventions have been conducted in America, Australia, and the United Kingdom and have focused mostly on primary school-children (Chillón, Evenson, Vaughn & Ward, 2011). Many single-component interventions such as cycle training courses (Ducheyne, De Bourdeaudhuij, Lenoir & Cardon, 2014), school travel planning (Rowland, DiGuiseppi, Gross, Afolabi & Roberts, 2003), and curricular-based interventions (Wen et al., 2008) have all shown only small or no effects on ATS. On the other hand, several studies showed that walking school bus interventions can increase walking behaviour in the short-term (Heelan, Abbey, Donnelly, Mayo, & Welk, 2009; Mendoza et al., 2011) and potentially over longer durations (Collins & Kearns, 2010; Mendoza, Levinger & Johnston, 2009). Walking school bus interventions are characterised by a group of children walking to school together along a set route. With adult supervision, children travel along set stops and collect more 'passengers' until they reach their school (Heelan, Abbey, Donnelly, Mayo & Welk, 2009). As was the case with PA, multi-component interventions promoting AT, that targeted children, parents, and communities, showed the greatest results (Chillón et al., 2011). Also, interventions that were predominantly focused on AT, rather than broader PA, showed even greater results (Chillón et al., 2011). For instance, the US SR2S Programme, that incorporated the combination of education, enforcement, and change of environment, showed a significant increase in ATS in the region of 5-20% (McDonald et al., 2013). The programme initially focused on curricular education and promotion of cycling and walking. Results showed an increase in cycling and walking of approximately 5% and 2%, respectively. The infrastructural component of this

programme was found to be particularly important. The addition of infrastructural changes into the programme, such as crossings or footpaths resulted in further increases in walking and cycling, of up to 20%. However, it is possible that such initiatives are more effective in countries with low baseline levels of ATS. In New Zealand, educational initiatives, enforcement activities and urban form changes around schools increased ATS from 40.5% to only 42.2% (Hinckson, Garrett, & Duncan, 2011). One of the most innovative developments in the area of health promotion is the use of technology and the concept of gamification as a strategy for influencing human behaviour change (Lister et al., 2014). The overview of the concept and the complexity of the topic is presented below.

2.6 Gamification of Physical Activity and Active Travel

2.6.1 Overview of the concept

As mentioned earlier, gamification is defined as 'the use of game design elements in a non-game context' (Deterding, Dixon, Khaled & Nacke, 2011, p.9). Gamification is based primarily on an intrinsic reward system and is anticipated to be more fun and enjoyable than conventional interventions, yet capable of producing desirable changes (Park & Bae, 2014; Seaborn & Fels, 2015; Furdu, Tomozei & Köse, 2017). In health-related settings, gamification can be explained as engaging and motivating 'players' to achieve specific health-related goals they may not even be aware of. For instance, in an active video game (AVG) such as Microsoft Kinect and Nintendo Wii, players are expected to move to perform specific tasks while playing the game physically. In location-based gaming, players evolve and progress via changes in their physical location (i.e. GPS) (Barnett, Bangay, Mckenzie & Ridgers, 2013). The exergames (serious games, i.e. 'Pokémon GO') simulate real-world events or processes designed to solve a problem. Although they can be entertaining, their primary purpose is to train or educate users, though they may have secondary purposes, such as marketing or advertising (Tong, 2015).

There are many behaviour change strategies inherent in gamification including self-monitoring and self-reflection, goal-setting, social communications and interaction, competition and collaboration, physical-activity-game mapping, and virtual rewards for games (Hardeman et al. 2000; Michie et al., 2013; Seaborn & Fels, 2015). Johnson et al. (2016) report that across all the interventions utilising the gamification concept, the most commonly employed elements are rewards, leader boards and avatars. By way of illustration, 'UbiFit Garden', uses a body sensor system with a mobile application to visualise users' daily steps by the growing status of plants. As the users meet their goals, their garden blooms and a yellow butterfly appears on display as a reward for their success (Consolvole et al., 2008). The mobile game 'Healthy Together', involves a pair of users that exercise together and earn badges as an incentive for walking and climbing. Users can compete with each other by earning more points for steps they have taken. Additionally, the game allows the users to communicate with each other via messages through the Healthy Together main interface (Chen, 2014). In another mobile game, 'Zombies, Run', players run, jog, walk, and complete missions trying to survive the zombie apocalypse. Throughout the game, the players listen to audio stories, collect supplies, and are continuously encouraged to stay active (Cowdery, Majeske, Frank & Brown, 2015). In the mobile game Pokémon Go, players explore real locations and search for virtual Pokémon creatures. Players are required to physically travel to specific locations to catch creatures, earn experience points, level up (progress to another game level), and eventually receive in-game rewards and bonuses. According to Althoff, White and Horvitz (2016), due to the high penetration level of the game (500 million downloads worldwide), 'Pokémon GO' can be viewed as a large scale intervention for PA.

2.6.2 The effectiveness of gamified interventions with adults

According to Johnson et al. (2016), the gamification concept in health promotion has been applied mainly in interventions among adults. The majority of gamified interventions have produced some positive effects (59%) on the studied population, while some reported mixed effects (41%) with mostly moderate and low-quality evidence provided (Johnson et al., 2016). As stated before, the Pokémon Go game achieved huge popularity in a brief period. Howe et al. (2016) looked at the impact of this game on the PA level of young adults in the US. Approximately 1200 individuals were recruited to partake in the study. Of these, 560 were categorised as players (minimum status of 'trainer level 5' within the game). A further 622 participants served as a control group as they did not play the game (non-players). Four weeks before commencing the game, the PA levels (step counts) of the participants were recorded to establish baseline PA levels while online surveys collected data on participant demographics. After six weeks of playing the game, the results were compared between the intervention and control group. In the intervention group, the number of daily steps increased significantly (955 steps; $p<0.05$) in week one before gradually returning to baseline levels. The number of daily steps in the control group remained at similar levels throughout the game. These results suggest that the game is likely to have had a modest health impact.

A similar research design was adopted by Nigg, Mateo and An (2017), who collected data using an online survey examining PA and sedentary behaviour (SB) before and after playing Pokémon GO. Data were collected from 486 young individuals fulfilling the study requirements. Nigg, Mateo and An (2017) reported that playing Pokémon GO increased MVPA by approximately 50 minutes per week and reduced SB by approximately 30 minutes per day ($p<0.05$). They also suggested that there may be greater benefits for people with higher BMI levels. Unfortunately, the description of methods in this study was superficial. There was insufficient detail about how long participants were playing the game before the survey was conducted and about the frequency of their play.

In contrast, Althoff, White and Horvitz (2016) focused on the impact of Pokémon Go on PA through a combination of wearable sensor data and search engine query logs for the game users. The researchers compared pre and post-game changes in PA among 1420 adult Pokémon Go players with a control group of 50,000 individuals (users of wearable technology and other mobile health apps). The findings of this study showed that Pokémon GO significantly increased the PA of the intervention group by as much as 26% (1437 steps a day on average). A different approach was taken by Wong, Turner, MacIntyre and Yee (2017) who investigated the effects of gamification on health beyond objectively measured PA. Their auto-ethnographic research on augmented reality games in public health interventions found additional positive effects such as increased encouragement for exercise and goal setting for exercise. The authors portrayed the Pokémon GO game as a catalyst for community socialisation and engagement in active pursuits in the evenings and after work. Furthermore, Wong et al. (2017) suggested that the game encouraged to travel to different locations by walking only, which therefore may have stimulated the creation of new, healthy habits.

2.6.3 The effectiveness of gamified interventions with school-children

The effects of gamified interventions in school-children are consistent with the results of interventions in adults. Sun (2013) examined the effect of active games on 70 primary school-children. Specifically, the study examined the impact on in-class PA intensity levels and perceived situational interest (the appealing effect of interaction with active games on children's engagement level). The intervention lasted six weeks and consisted of playing active games (i.e. game bikes, Xavix boxing, 3-kick, Nintendo Wiis) during PE classes. The children's baseline and follow-up PA levels were measured by accelerometers, which were worn during each PE class. Situational interest was measured using the Situational Interest Scale (Sun et al. 2008) at the end of the intervention. Results showed that the active games elicited significantly ($p<0.001$) higher METs (metabolic equivalent of task) at follow-up than at baseline. In contrast, perceived situational interest was low to moderate at follow-up and dropped considerably over time. These findings

suggest that active games may enhance PA in PE; however, the sustainability of the effects is questionable.

Garde et al. (2018) looked at the effect of a two-week mobile exergame in thirty-seven primary school-children from Vancouver, Canada. Children were randomly assigned to an intervention (n=19) and control (n=18) group. All participating children were required to wear an activity tracker during the intervention period that measured steps and active minutes. However, only the intervention group was provided with the 'MobileKids Monster Manor' game. The game consisted of monster characters that could be unlocked after completion of PA challenges within the game. Children were assigned to small groups and could interact with each other via pre-set messages. The results showed that, in the intervention group, PA increased by 1,758 steps/day (12.6% greater than baseline) and 31.3 active minutes/day (13.6% greater than baseline) after the intervention ($p<0.004$). In the control group, there were no changes in PA from baseline to follow-up. The increase in PA was significant from week one of the intervention. However, similar to Sun (2013), it could not be maintained throughout the intervention, suggesting that these games only have a short-term intervention effect.

2.6.4 The persuasive architecture of gamification

A review of the literature on the topic of the efficacy of gamification implies that for the gamified intervention to be effective, some aspects of the game design, specifically elements employing behaviour change, cannot be overlooked (Cugelman, 2013; Orji, Tondello and Nacke, 2018). Cugelman (2013) suggest that technology is only influential when it employs specific behaviour change elements called persuasive strategies. The combination of these persuasive strategies is, in turn, referred to as the persuasive architecture (Cugelman, 2013). Cugelman (2013) identified seven persuasive architecture elements of gamification that have been positively associated with behaviour change.

The first element, goal setting, is explained as constructing or following a given set of behaviour goals and working towards achieving it (Cugelman, 2013; Tondello, Premsukh and Nacke, 2018). These goals can be presented

as quests or outcomes to be pursued (Tondello, Premsukh and Nacke, 2018). According to Tondello, Premsukh and Nacke (2018), the potential tools for goal setting in gamification are often presented as badges, leaderboards, levels, progress bars, rules, goals, challenges, points, achievements, and rewards. The second element of persuasive architecture in gamification is the capacity to overcome challenges. This provides the player with an opportunity to grow, learn, and develop through the game (Cugelman, 2013). The third element is delivering feedback on the player's performance. According to Cugelman (2013), provision of feedback throughout the game allows people to track their behaviours and compare their current performance with previous efforts. Monitoring progress can also be achieved by providing a means (such as leaderboards) for the user to view and compare their performance with the performance of other users. Another element of the persuasive architecture of gamification is reinforcement. Players are offered virtual rewards for performing a target behaviour and penalised for not performing the desired behaviour or reaching their goal (i.e. removing acquired rewards). Cugelman (2013) refers to social connectivity as the sixth element of the persuasive architecture of gamification.

Social connectivity is about providing an opportunity for players to interact with other players in the game. The final element is the fun and playfulness associated with playing out an alternative reality. According to Cugelman (2013), the combination of these elements with the most popular gamification tactics may provide a potentially promising framework for digital health interventions. However, research shows that the majority of gamified interventions and health apps do not utilise sufficient elements of the persuasive architecture (Lister et al., 2014; Seaborn and Fels, 2015). Likewise, the majority of the gamified interventions rely solely on just one game element, which, in turn, greatly reduces the possibility of an intervention effect (Sardi, Idri and Fernández-Alemán, 2017). According to Orji, Tondello and Nacke (2018), the gamification approach may not be suitable for everyone, and that a participant's characteristics may affect the outcomes of gamified interventions. Therefore, gamified interventions need to be more user-centred and look at the characteristics of potential users (Orji, Tondello and Nacke, 2018; Sardi, Idri and Fernández-Alemán, 2017).

2.6.5 The effectiveness of BTS

Beat the Street is delivered internationally by an Intelligent Health Ltd (UK) company. So far, there have been 810,710 BTS players worldwide. In 2016 alone, 300,000 people played the game across 21 different world-wide locations (Intelligent Health, n.d.).

Beat the Street was previously evaluated by Hunter et al. (2015). A total of 3817 children from twelve primary and secondary schools in England and Canada (London, Reading and Vancouver), took part in a four-week walking intervention. The intervention looked only at trips to and from school. At baseline, participating children recorded their usual mode of travel and the duration of the journey (in minutes) using a five-day diary. At follow-up, the data was collected through swipe card technology. Other outcome measures included attitudes towards walking and social aspects of PA. This data was collected at baseline and in week four, immediately post-intervention. At baseline, 54% of children taking part in the intervention completed the questionnaire data with 27% completing it immediately post-intervention. A qualitative sub-study involving focus groups with children, parents, and teachers provided further insight. At follow-up, 76% of children reported walking on five or more journeys to or from school in the past week compared to 68% at baseline. Similarly, 86% of children walked to school at least once a week at follow-up, compared to 77% at baseline. As was the case in the studies mentioned previously, there was a gradual decrease in the proportion of children walking to and from school over the four weeks (29% in week one, 18% in week two, 14% in week three and 12% in week four). Overall, 97% of children who took part in follow-up surveys felt that walking to school helped them stay healthy, 81% felt happy doing it, and 76% said it helped them stay alert in class. Furthermore, 69% of children felt calmer, and 63% could concentrate more in class. The results showed that the key motivating factors for playing the game were; having fun, enjoyment (scanning cards and noises), and spending time with friends. The main limitation of this research was the lack of a control group that would have facilitated a between-group comparison of the effect of the intervention. The results showed some discrepancy between walking levels collected using self-report questionnaires at baseline and the

swipe card technology. Another reported limitation within this study was the poor response rates for the questionnaire at baseline and follow-up. Finally, although the competition element of the game was found to be an important factor related to participation in the game, it was sustainable only for a short period.

Another evaluation of BTS took place in Norwich in the UK and looked at the effect of a nine-week BTS intervention on primary school-children's mode of travel to school and the intensity of their PA time (Coombes & Jones, 2016). A total of 107 primary school-children from two schools (n=51 in control and n=56 in intervention school) were invited to partake in the study. The intervention took place from May to July 2014 and included three data collection points: baseline, mid-intervention and post-intervention. The baseline data were collected from 80 children, mid-intervention data from 71 and post-intervention from 75. The baseline and mid-intervention data collection took place during the school summer term, whereas the post-intervention data collection took place in the autumn term following the six-week school summer holidays. At each data collection point, children provided information about their demographics, completed simple travel diaries regarding their mode of travel to and from school, and wore an accelerometer for seven days. The intervention included swipe card technology and 40 readers located mainly at lampposts located within a 0.5-mile radius of the school. The findings showed no significant differences between baseline and mid-intervention follow-up (p=0.328), with both intervention and control schools showing an increase in AT. However, between baseline and post-intervention follow-up, there was an increase in AT only at the intervention school (+10.0% per child per week, equivalent to one additional AT journey out of a possible ten). At the same time, ATS decreased at the control school (-7.0%, p>0.05). What is more, Coombes and Jones (2016) found that a higher percentage of children (66.7%) maintained or increased their frequency of ATS post-intervention in the intervention school compared with the control school (55.6%). Additionally, four children from the intervention school switched from a passive to an active mode of travel to school, with no changes in the control school. Overall, PA levels did not increase at follow-up in either school. However, there was a positive

association between MVPA during ATS and the number of days on which children tapped a BTS sensor. This equated to an extra 3.46 minutes of daily MVPA during commute times for children who touched a sensor on 14.5 days (the mean number of days), compared to those who did not engage with the intervention.

A more recent evaluation of the BTS intervention by Harris (2018) showed more positive results. The author looked at the effect of a BTS intervention in Wolverhampton, England. The intervention took place for seven weeks and engaged 8345 participants (11 to 80 years old), of which 329 provided baseline and follow-up data. As was the case previously, participants collected points by tapping the BTS sensors located around the city. While registering their card, participants were invited to complete a questionnaire to record sociodemographic and PA information. At follow-up, (immediately after week seven of the intervention) all registered participants who agreed to be contacted (n=3315) were sent a link to a follow-up survey via email. A £50 prize draw was offered as an incentive for completion of a follow-up survey. The findings showed that participants increased their weekly walking by 180 minutes per week ($p<0.001$) and their METs from a median of 2772 METs at baseline to 4266 METs at follow-up. Furthermore, Harris (2018) reports that participants increased their weekly PA by a median of 335 minutes per week ($p<0001$). Finally, there was no change in sedentary time between baseline and follow-up, with the median value reported at both time points as 2100 minutes per week.

2.7 Conclusion

The promotion of AT is one potential way of improving the levels of PA in school-children. Ireland is very dependant on the car as a mode of transport to places. The proportion of school-children walking and cycling as a means of travel to school has decreased considerably in recent decades. Recently, researchers and practitioners have taken advantage of new technologies, and their accessibility, to create a new concept of gamified interventions. Gamified interventions promote behaviour change through fun, game-like programmes that offer a novel approach to changing health and travel behaviours. However, there are only a limited number of empirical studies that have evaluated their effectiveness. The main purpose of this study is to evaluate the effectiveness of a seven-week gamified intervention on PA and AT in school-children.

3 Methodology

3.1 The Beat the Street Project in Waterford

In 2017, Intelligent Health Ltd. was commissioned to implement BTS for the very first time in Ireland. Three locations were chosen to pilot the project: Dublin, Waterford, and Limerick. The seven-week project in Waterford took place in Waterford city, Kilmacthomas, and Dungarvan. The project was implemented directly by Intelligent Health Ltd. with support from Waterford Sports Partnership and funding from Sports Ireland, Healthy Ireland, Dormant Accounts, and Waterford City and County Council (WCCC). The BTS project began on Wednesday, October 13th, 2017 and finished on Wednesday, November 31st, 2017. The programme targeted both school-children and adults and aimed to increase PA levels through walking and cycling across the community. The researcher was entirely independent of the design and implementation of the game. The focus of this research study was also limited to Waterford City only. This was necessary due to the large sample sizes required for repeat cross-sectional designs.

There were forty-eight boxes installed on lamp posts in Waterford City and three on the Greenway near to Waterford City. The map locating BTS boxes was available to view online through the BTS Waterford website (https://beatthestreet.me/waterford/home) under the 'How to play' section (see Appendix A). The BTS cards/fobs and hard copies of the maps were available to collect from eleven distribution points in the region and seven in Waterford city (see Appendix B). Primary and secondary schools that agreed to take part in the initiative were provided with a starter pack including an introductory letter, school banner, posters/flyers, parent packs (letter and one card), cards/fobs (staff and spares), and maps (see Appendix C). Fobs provided to primary schools were already pre-registered to their respective schools for the purposes of the team competition. Participants competed against other teams by collecting as many points as possible. Players were able to view their place on the leader board throughout the game (see Appendix D). In the end, the best three teams on a leader board were awarded cash prizes (1st place-500 euros, 2nd place-250 euros, 3rd place-100 euros) and fitness vouchers for the entire team. Every week, there were

additional prizes to be won by individual players, all advertised through social media channels (see Appendix E). Overall, the BTS Waterford marketing campaign gained 1108 followers on Facebook and Twitter throughout the game.

3.2 Research Design

This was a repeat cross-sectional[2] study of a seven-week PA intervention targeting school-children. The intervention commenced on Wednesday, September 13th and finished on November 31st, 2017. Seasonally matched self-reported surveys were collected in twenty-four intervention schools (sixteen primary and eight secondary) and two control primary schools (there were no control schools for the secondary school sample). Baseline surveys were conducted in October 2016 with follow-up surveys in November 2017. Ethical approval was granted by the Waterford Institute of Technology's Research Ethics Committee in June 2016 (Appendix F).

3.3 Research Questions

The primary aim of this study was to examine the extent to which BTS can create a modal shift to active travel among school-children.

The specific research questions are as follows:

1) What were the characteristics of the sample?
2) Who played BTS and how frequently did they do so?
3) How aware were school-children of BTS?
4) What impact did BTS have on active travel to school
5) What impact did BTS have on PA in school-children?
6) What are the factors that influence active to school among school-children?
7) What did school-children perceive to be the strengths and weakness BTS?

[2] Repeat cross-sectional design in this study measures different children at each time point. That is, 1st year students in 2016 can be compared to 1st year students in 2017.

3.4 Study Population and Sampling

The population of interest in this research were children attending primary and secondary schools in Waterford City. In 2016, schools that could be involved in the study were identified by WCCC. In May 2016, WCCC, in conjunction with Waterford Institute of Technology (WIT), sent letters to all school principals requesting permission to conduct the surveys in October 2016 (Appendix G). Permission was duly granted in eighteen out of nineteen primary schools and in nine out of ten secondary schools. At the beginning of October 2016, an information letter (Appendix H) was sent home to the parents of all 5th and 6th class children and 1st, 2nd and 5th-year children of participating schools. This letter sought the passive consent of parents for their child to complete the survey.

In 2017, Intelligent Health Ltd. representative recruited Waterford primary and secondary schools to participate in the BTS project. Information on which schools agreed to take part in BTS was communicated to the researcher by Intelligent Health Ltd. Researcher and the research team had no involvement nor influenced the recruitment process in any way. In September 2017, letters requesting permission to conduct the follow-up surveys in November 2017 (Appendix I & Appendix J) were sent to all schools that took part in baseline data collection. Permission was duly granted in the eighteen primary schools from baseline and eight out of the nine secondary schools from baseline. At follow-up, a decision was taken to exclude 2nd and 5th-year students from the study. This decision was made in consultation with Intelligent Health Ltd. who advised that adolescents did not typically engage with the game. In October 2017, a parent information letter (Appendix K) was sent to the parents of all 5th and 6th class children and 1st-year children of participating schools. As before, this letter sought the passive consent of parents for their child to complete the survey. Only one primary school child was withdrawn from the study. At follow-up, two primary schools out of the eighteen surveyed did not partake in the BTS project and therefore served as control schools. There was no control group for secondary school sample as all schools that were surveyed were participating in BTS.

3.5 Data Collection Tools

3.5.1 Primary schools

The instrument used for the primary school data collection (Appendix L), was a three section self-reported questionnaire adapted from an evaluation of a similar Smarter Travel programme (Lambe, 2015). The first section of the questionnaire was about student demographics and included questions such as age, sex, and school year. Section two measured the usual mode of travel to school (walk, cycle, car, bus or other) and PA levels. The usual mode of travel to and from school, as well as the preferred mode of travel, were measured separately. Illustrations of each travel mode were provided adjacent to the text. Children were asked to think of the longest part of their journey. Questions on independent mobility and household car availability were also included. Physical activity level was measured by asking children to tick the box corresponding to the number of days they were physically active for a total of at least 60 minutes on each of the last seven days. This one item question was developed and validated by Milton, Bull and Bauman (2011). The third section of the survey measured children's awareness of AT campaigns in their school and Waterford City. This section contained questions about awareness of school initiatives promoting walking or cycling and changes in Waterford City to facilitate AT. The survey took between 10-15 minutes to complete. The primary school survey was piloted with approximately twenty children (aged 10-13 years) from Waterford City. No changes were made after the pilot study.

At follow-up, sections one and two of the baseline survey remained the same. However, the third section was supplemented with specific questions regarding BTS (Appendix M). Questions 15 and 16 measuring children's awareness of AT campaigns in their school remained unchanged, however questions 17, 18 and 19 from the original survey, were taken out. An additional nine closed questions and one open question were included in their place. These questions asked if children received a fob key from the school, who they played the game with, the frequency of their play and overall participation in BTS, as well as the things they enjoyed most and their ideas for improving the game. The follow-up survey was piloted with approximately

twenty primary school-children (aged 10-13 years), and there were no changes made afterwards.

3.5.2 Secondary schools

The instrument used in the secondary school data collection (Appendix N) was a seven-part questionnaire adapted from a previous evaluation of a Smarter Travel programme (Lambe, 2015). The instrument was supplemented with several additional questions. The survey was extended to include the number of cars available in the household (Q.5), parental trip chaining (Q.14), the usual mode of travel from school (Q.15), independent mobility (Q.20) and habit strength (Q.21 & Q.22). The section about measuring levels of PA was changed to a one-item question developed and validated by Milton, Bull and Bauman (2011). The Adolescent Survey was piloted with approximately twenty children (aged 15-17 years) from Waterford City. No changes were made after the pilot study.

The first section of the survey was about student demographics and included questions such as age, sex, and school year. The second section assessed total PA, which was measured by a single-item PA measure developed and validated by Milton, Bull and Bauman (2011). The third section (Q.7-Q.12), contained questions related to the number of days and time spent in various modes of transport over the previous seven days. This was adapted from the 'Healthy Lifestyle in Europe by Nutrition in Adolescence' (HELENA) study instrument (Moreno et al., 2008) which itself was based on the International Physical Activity Questionnaire for adults aged 18-65 years (Craig et al., 2003). The fourth section included predominantly multiple choice and dichotomous questions. These questions related to the actual mode of travel to and from school, preferred method of travel to school, parental trip chaining, perceived distance from home to school, bicycle access, and independent mobility (Q.13-Q.20).

The next section (section five) measured the strength of the habit of driving and walking to school. This was done using the 12-item Self-Report Habit Index (SRHI; Verplanken & Orbell, 2003) that measures the main features of habit; frequency of the behaviour, behavioural automaticity, and identity

expression. Responses were recorded on a five-point Likert scale, with one being ‘strongly disagree’ and five being ‘strongly agree’. The mean of all twelve served as the final measure of habit strength for walking and driving. Section six looked at the respondents’ attitudes towards walking and cycling to school. This section contained 36 statements (20 for cycling and 16 for walking) related to the individual, social, and environmental factors that influence ATS. Again, responses were recorded on a five-point Likert scale with scores ranging from one (strongly disagree) to five (strongly agree). The mean of all answers served as the final measure of their attitude towards the specific behaviour. This section was adapted from Emond and Handy (2011). The final section (section seven) of the survey measured children’s awareness of AT campaigns in Waterford City and was adapted from a previous evaluation of a Smarter Travel programme (Lambe, 2015). This section asked respondents if they could recall any events or activities related to AT in their town. They were asked to name and provide details of the event or activity. The survey took 10-15 minutes to complete.

At follow-up (Appendix O), the secondary school survey had to be updated to accommodate questions regarding the BTS intervention. Sections one to four of the original survey remained unchanged. However, after consideration, section five (strength of the habit of driving and walking to school) was removed to keep the questionnaire more concise and easier to complete. Section six (attitudes towards cycling and walking) remained unchanged. Similar to the primary school questionnaire, the final section of the questionnaire (‘Questions about promoting physical activity in Waterford City’) was supplemented with more specific questions regarding the BTS intervention (10 closed questions and one open question). These questions asked if children received a fob key from the school, who they played the game with, the frequency of their play, and overall participation in BTS, as well as the things they enjoyed most and their ideas for improving the intervention. Questions regarding changes in Waterford City (Q.28 & Q.29) were removed at follow-up, and Q.25 was changed to ask about any special events or campaigns encouraging PA or AT (Appendix O). The follow-up survey was piloted with approximately twenty secondary school-children (aged 15-17 years), and there were no changes made afterwards.

3.6 Data Collection Method

3.6.1 Primary schools

Baseline data in primary schools were collected by the researcher and two trained research assistants. In September 2016, the researcher contacted the primary school principals to arrange a date to administer the surveys at a convenient time for the school. Afterwards, an information letter (Appendix H) was sent home to the parents of all 5th and 6th class children. All baseline primary school data was collected between the 30th of September 2016 and 21st of October 2016. The questionnaires were completed during class time, and the process was facilitated by the researcher or one of the two research assistants, using standardised instructions (Appendix P). The researcher explained these instructions to the research assistants before commencing data collection. Children completed the survey one question at a time and only after the question was explained to the class by the researcher or research assistant. The question was then answered simultaneously by the class. In other words, all children completed the questionnaire at the same time. There were no requests to withdraw a student from the study.

Follow-up data in primary schools were collected by the researcher and two trained research assistants. As before, schools were contacted beforehand to arrange a date to administer the surveys and parent information letters were sent home to the parents of all 5th and 6th class children. The follow-up data from primary schools were collected between October 13th, 2017 and October 22nd, 2017. Following the same procedures as a baseline, the questionnaires were completed during class time, and the process was facilitated by the researcher or one of the two research assistants, using standardised instructions (Appendix P). As mentioned previously, there was one request to withdraw a student from the study.

3.6.2 Secondary schools

The principals of the participating nine secondary schools were contacted in September 2016 to arrange a date to drop off and collect the surveys. The schools were instructed to facilitate the completion of the questionnaire during class time and leave the completed surveys in the school's administration office for collection. Two secondary schools requested the assistance of the research team with conducting the surveys. In these schools, a convenient date and time to conduct the survey were arranged. The researcher disseminated the questionnaires to children during class time but did not advise on how it should be completed. After completion, the surveys were collected by the research team. All secondary school data were collected between October 3rd, 2016 and November 9th, 2016. There were no requests to withdraw a student from the study.

At follow-up, all principals from eight participating secondary schools were contacted in October 2017 to arrange a date to drop off and collect the surveys. Participating schools were instructed to facilitate the completion of the questionnaire during class time and leave the completed surveys in the school's administration office for collection. Three secondary schools requested the assistance of the research team with conducting the surveys. At a prearranged time, the researcher disseminated the questionnaires to children during class time and collected them once completed. All secondary school data was collected between October 13th, 2017 and October 24th, 2017. There were no requests to withdraw a student from the study at baseline or follow-up.

3.7 Data Analysis

The data analysis was conducted using IBM SPSS Statistical Package 21 and in Microsoft Excel 2016. Descriptive statistics were calculated via means, standard deviations, and frequencies where appropriate. Chi-square was used to examine cross-sectional differences between categorical and continuous variables, respectively. The absolute change in the proportions (difference in differences) of children engaging in AT and their preferences to do so, were calculated using 95% confidence intervals consistent with previous research (Lambe, 2015). Binary logistic regression analysis was conducted to examine the factors associated with ATS among primary school-children. Likewise, binary logistic regression was done to investigate the likelihood of meeting the PA guidelines according to the extent of a student's participation in AT and the BTS intervention.

3.8 Ethical Consideration

Ethical approval for WIT's participation in the BTS project was applied for and granted by the Research Ethics Committee in the Department of Health, Sport and Exercise Science in Waterford Institute of Technology. Passive consent for children to complete the survey was granted by their parent. An informational letter that was provided to parents explained the scope of the research, and questions that will be asked via a short questionnaire during class time. The letter clarified that only researchers involved with the study will have access to a child's information. However, children will not provide their name or address, so the questionnaire will be anonymous. The surveys and results were stored in a secure and locked location; in a locked filing cabinet and in an encrypted electronic file. Parents were informed that participation is voluntary and if they would rather withdraw their child participation from the study, then they would have to contact the researcher directly as per the contact details provided.

4 Results

This chapter presents the findings related to the study research questions. The data for primary and secondary school students are presented together where the same questionnaire items were used. Correspondingly they are presented separately for variables where different measurement items were used. As outlined in the methods section, different measurement items were used to account for a student's ability to self-report data according to their age.

4.1 Characteristics of the sample

Note: The data below is from the survey of school-children.

The characteristics of the primary school sample at baseline (pre) and follow-up (post) are shown in table 4.1. The survey response rates were 92% at baseline and 94% at follow-up. The characteristics of the secondary school sample at baseline and follow-up are shown in table 4.2. The response rate at baseline was calculated as 67%. At follow-up, the response rate was 69.9%. A 100% response rate was not achieved due to school events and non-attendance. At baseline, data was collected from 1289 children from eighteen primary schools (sixteen intervention schools and two control schools) in Waterford City, and the follow-up data was collected from 1293 pupils in the same eighteen primary schools. In secondary schools, the baseline data was collected from 603 children from nine schools, whereas follow-up data was collected from 483 children from eight schools. One of the schools surveyed at baseline declined to participate at follow-up and therefore, was not included in the data collection process.

In primary school sample, there was a greater proportion of females than males in the intervention group at both time points (56.7% vs 43.3% at baseline, and 60.5% vs 39.5% at follow-up; $p<0.001$). Conversely, there was a greater proportion of males than females in the control group at both time points (65% vs 35% pre, and 59.8% vs 40.2% post; $p< 0.001$). In the control group at baseline, a higher proportion of respondents were in 5^{th} class compared with the 6^{th} class (60.2% vs 39.8; $p<0.05$). Despite this, there was no difference in the average age of children in the control group at baseline

and follow-up (p>0.05). Overall, 84.7% of all primary school-children reported owning a bicycle at follow-up. In the intervention group, a greater proportion of females owned a bicycle (60.5% versus 39.5%; p<0.05). Conversely, in the control group, a greater proportion of males owned a bicycle (55.6% vs 44.4%; p<0.05). In the total sample of primary school-children, each household had an average of 1.6 cars (±0.76).

Table 4.1. Sample characteristics at baseline and follow-up in intervention and control schools

	Intervention		Control	
	PRE (n=1166)	POST (n=1191)	PRE (n=123)	POST (n=102)
Age (years, mean ± SD)	10.8 (0.71)	11.0 (0.72)	10.8 (0.72)	11.1 (0.77)
Sex (%)				
Male	43.3	39.5	65.0**	59.8**
Female	56.7**	60.5**	35.0	40.2
Class (%, n)				
5th	50.4 (584)	49.0 (578)	60.2* (74)	49.0 (50)
6th	49.6 (575)	51.0 (602)	39.8 (49)	51.0 (52)
Own bicycle (%, n)				
Male	43.3 (428)	39.5 (395)	63.9 (62)	55.6 (50)*
Female	56.7 (561)	60.5 (605)	36.1 (30)	44.4 (40)
No. of cars in household (n, mean ±SD)	1.6 (0.76)	1.6 (0.76)	1.6 (0.67)	1.7 (0.66)

**p<0.05, **p<0.001*
(n) Denotes the number of participants that equates to the given percentage

In secondary school sample, at both time points, there were significantly more male than female participants (see table 4.2). At baseline, almost 58% of the children were males (p<0.001), whereas, at follow-up, this proportion was over 61% (p<0.001). The majority (66.8%) of children owned a bicycle. At baseline, over 70% of males claimed to own a bicycle, compared with almost 62% of females (p<0.005). At follow-up, a greater proportion of females than males owned a bicycle (74% vs 67% respectively; p<0.005). Overall, the proportion of children owning a bicycle was significantly higher at follow-up than at baseline (69.3% vs 66.8%; p<0.05). At baseline, males reported a significantly longer journey distance to a school than females (8.8km ± 9.0 vs 5.1km ± 5.0; p<0.05).

Table 4.2. Sample characteristics at baseline and follow-up by sex in secondary school-children

	PRE (n=603)			POST (n=483)		
	Male	Female	All	Male	Female	All
% (n)	57.5 (347)**	42.5 (256)**	37.3 (603)	61.3 (296)**	38.7 (187)	100 (483)
Age (years, mean ± SD)	12.4 (0.57)	12.3 (0.49)	12.4 (0.53)	12.6 (0.63)	12.5 (0.67)	12.6 (0.65)
Own bicycle (%, n)	70.2 (240)***	61.9 (156)	66.8 (398)	66.6 (191)	73.7 (137)***	69.3 (328)*
No. of cars in household (n, mean ±SD)	1.7 (0.85)	1.5 (0.81)	1.7 (0.84)	1.4 (0.73)	1.7 (0.79)	1.7 (0.78)
Journey time to school (min., mean ± SD)	19.5 (15.47)	18.0 (15.01)	18.8 (15.3)	20.7 (14.6)	20.0 (17.2)	20.4 (15.6)
Journey distance to school (km., mean ± SD)	8.8 (9.00)*	5.1 (4.98)	7.3 (7.84)	7.46 (8.26)	8.4 (8.67)	7.8 (8.40)

**p<0.05, **p<0.001, ***p<0.005*

4.2 Who played BTS and how frequently did they do so?

Note: The data below is not from the survey of school-children but from raw data provided by Intelligent Health to the researcher. It also includes all players in Waterford City and is not just limited to school-children. However, it is envisaged that approximately 80% of all players are schoolchildren. This data is included because it illustrates important characteristics of the game, such as trends in participation levels and the most popular days and times for playing. Change in the frequency of playing BTS over the seven weeks.

4.2.1 Change in the frequency of playing BTS over the seven weeks

There was a total of 166,905 taps registered on the 51 boxes in Waterford City. This represented an average of 3303 taps per Beat Box (including data from four boxes before they were vandalised). Figure 4.1 highlights that the majority of the taps took place within the first two weeks of the game (54.8%, n=91453). In the first day of the game, there were 7.5 taps per minute

throughout the 24 hours[3]. Then in the first week of the game, this dropped to 5.6 taps per minute. After the initial two-week period, the participation level declined further.

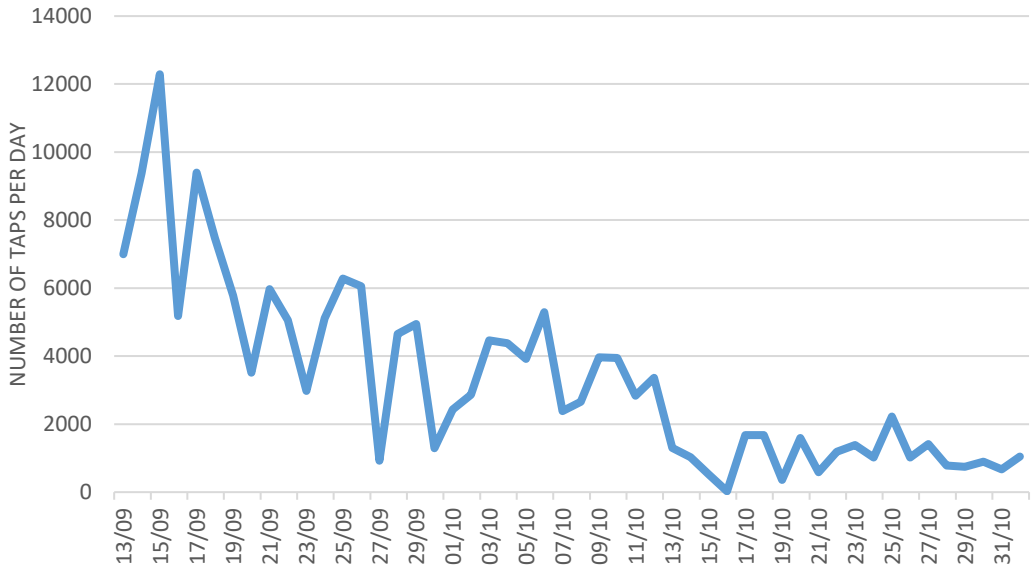

Figure 4.1. Total number of taps per day in Waterford City during the BTS game

4.2.2 The most common days and times for playing BTS

In Waterford City, the BTS game was mostly played during weekdays (Monday to Friday) with a considerable decrease in participation at the weekends (see figure 4.2). The days with the highest and lowest numbers of taps were Friday (19.1% of all taps) and Saturday (8.7%), respectively. The majority of box taps on weekdays took place between 8am-9am (11.2%) and 2pm-3pm (13.7%) suggesting that many school-children played the game on the journey to and from school (see figure 4.3).

[3] Data referring to time of day includes all 3 sites in County Waterford (Waterford City, Kilmeaden & Dungarvan)

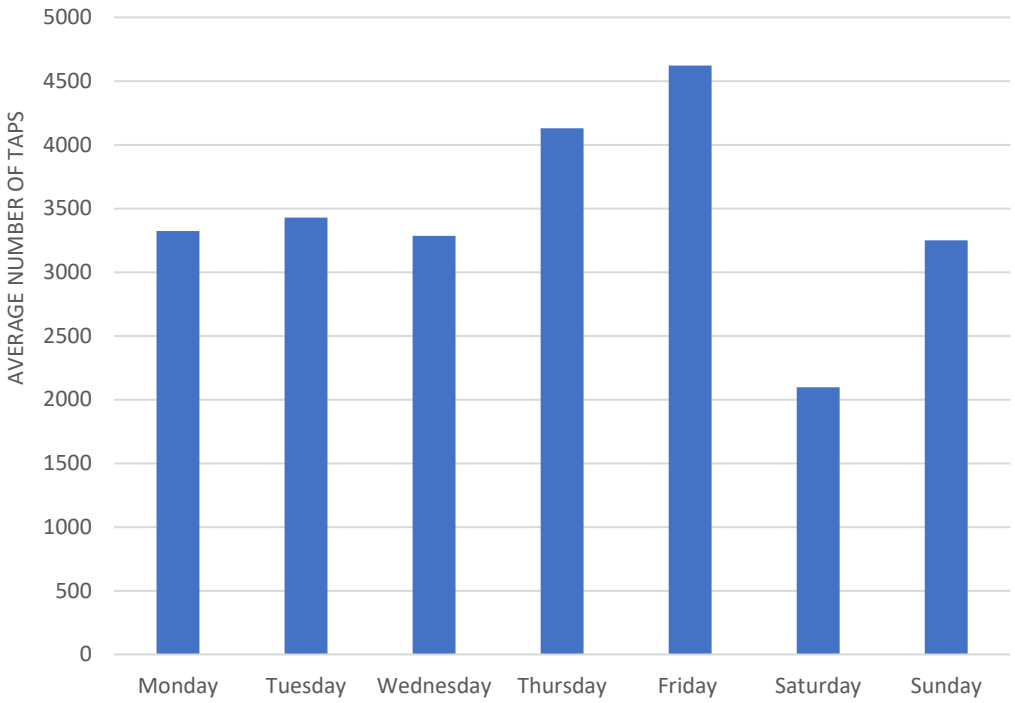

Figure 4.2. The average number of taps on each day of the week in Waterford City

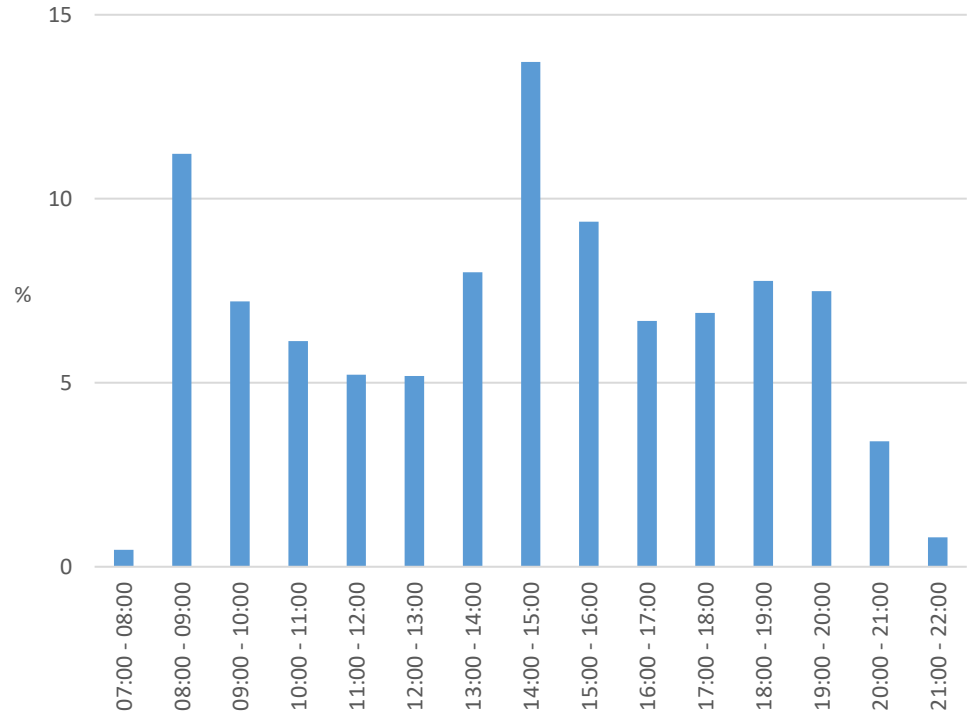

Figure 4.3. The proportion of Beat Box taps during each hour of the day (weekdays only) in Waterford City and County (3 sites)

4.2.3 The engagement of Waterford schools with BTS

There was a considerable difference in engagement with BTS between primary and secondary schools (see figure 3.7 + Appendix Q). For instance, there were 5,771 registered players from primary schools, who collected 576,610 points altogether throughout the game[4]. In contrast, there were only 659 registered players from secondary schools who collected a total of 37,560 points. Likewise, there was a noticeable variation in the extent of engagement between schools regardless of the number of children attending the school (see Appendix Q). The primary school with the highest level of engagement had 474 members (260 children) with an average of 202 points per team member. In contrast, the primary school with the 2nd highest level of engagement had almost twice as many members (892 members of which 687 were children enrolled in school) and 98 points per team member. The primary school with the lowest level of engagement had 248 members and 25 points per team member (348 children enrolled in school). The location of the boxes and the schools were both influential in predicting the engagement of school-children with the BTS game.

Nonetheless, these were not the only factors that influenced player engagement. For instance, one of the schools at the top of the leader board (with a total of 59,850 points) was not located in the city centre and did not have a high density of beat boxes in its vicinity. Furthermore, two schools with the lowest average points per team member were located in areas with, arguably, good street connectivity but also with high levels of deprivation. One of these schools was located near to where several of the boxes were vandalised and decommissioned. Finally, two adjacent schools had very different levels of engagement with BTS (see figure 4.4 below).

[4] Data refers to children, their parents/guardians and school staff

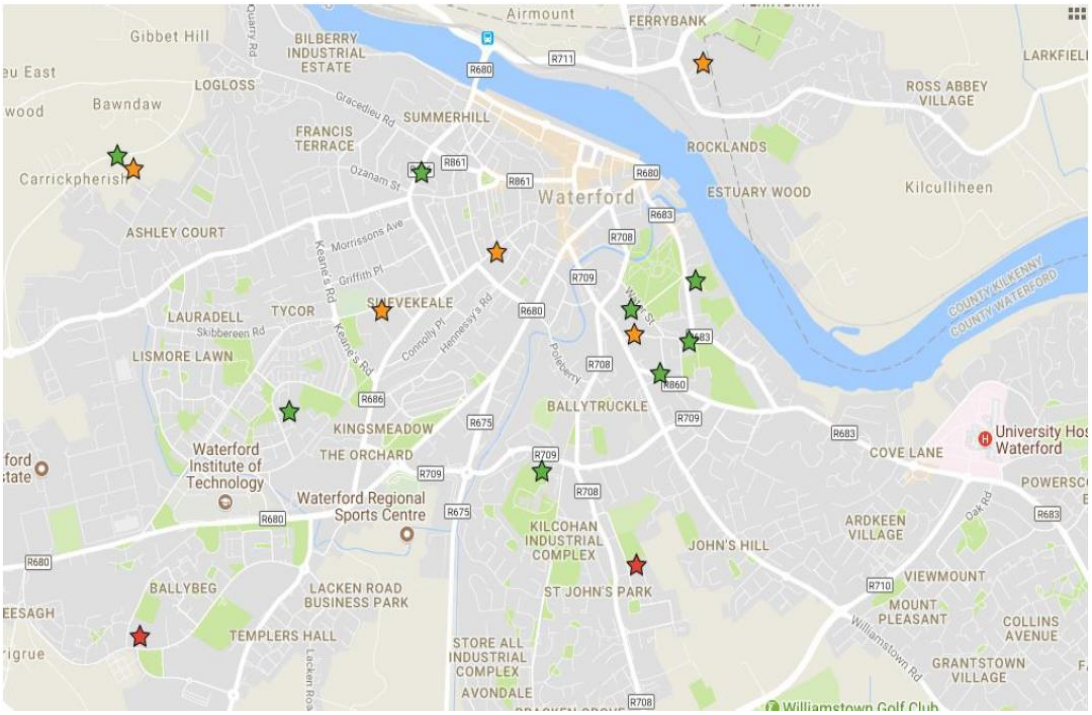

Figure 4.4. Location of primary schools in Waterford City and their level of participation in BTS

School (high participation)

School (mod. participation)

School (low participation)

4.2.4 Engagement of primary and secondary school-children with BTS

Note: The data below is from the survey of school-children.

Overall, 98.5% (n=1142) and 57.9% (n=210) of primary and secondary school-children, recalled receiving a BTS card at school, respectively. Secondary school-children showed a lower engagement with the game when compared with primary school-children. For instance, 38.3% of secondary school-children claimed they never played the game. This was higher than reported for the primary school-children (15.3%; see figure 4.5). Nevertheless, 66.1% and 45.5% of participating primary and secondary school-children claimed to play the game every week (see figure 4.5; once a week, several times a week, every day). Females at primary and secondary

level were significantly (p<0.001) more likely to play the game regularly when compared to males (see figure 4.5). In primary schools, almost 18% of females played the game every day in contrast with 9% of males. Correspondingly, 8.4% of females never played the game compared with 26.4% of males. In secondary schools, more than 67% of females played the game every week, in contrast with 35.2% of males (p<0.001). Correspondingly, a greater proportion of males claimed never to have played the game (47.9% vs 17.9%; p<0.001).

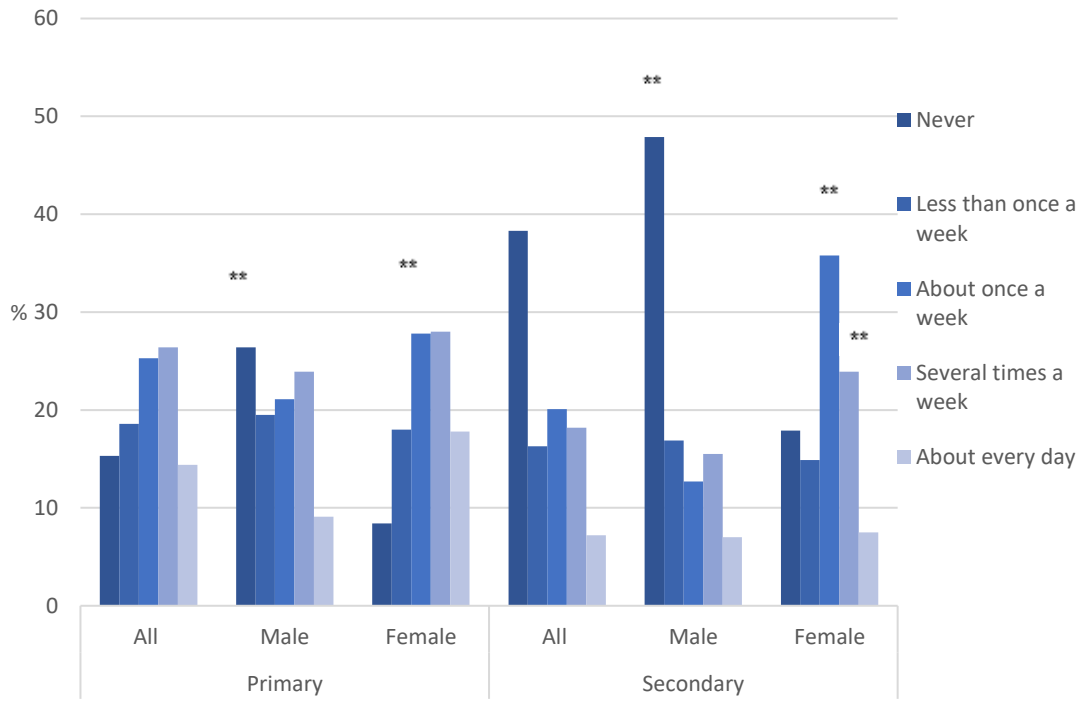

Figure 4.5. How frequently primary and secondary school-children played BTS
***p<0.001*

The majority of primary school-children played the BTS game with their parents or other adults (42.3%) while only 15.2% said they played the game on their own (see figure 4.6). There was a gender difference in the proportion of school-children that played the game on their own. Almost 22% of males stated that they played the game 'mostly on their own' compared with only 11.8% of females (p<0.001). Conversely, a greater proportion of females

played the game with friends when compared with males (18.5% vs 10.4%; p<0.001). Unlike the primary school-children, children at secondary level played the game most commonly with their friends (52.1%; see figure 4.6). Expectedly, a greater proportion of children played the game without adult accompaniment (22.7%) when compared with primary school-children (15.2%). There was a gender difference in the proportion of children that played the game with their friends during school hours (p<0.001). Females were more likely to play the game with their friends during school hours than males were (57.4% vs 4.2%; p<0.001) indicating that some schools integrated BTS into the curriculum.

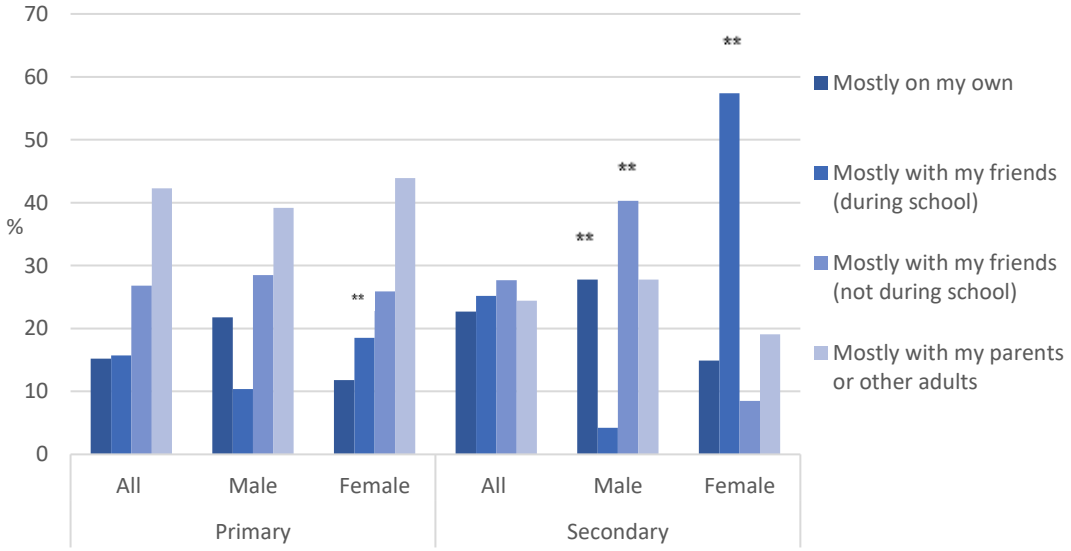

*Figure 4.6. Who the primary and secondary school-children played BTS with **p<0.001*

4.3 How aware were school-children of BTS?

Participating children were asked two questions regarding ATS/PA interventions in Waterford City. The first question asked about their general awareness (unprompted awareness) of interventions promoting ATS or PA in Waterford City. The following question asked explicitly about their awareness of the BTS intervention (prompted awareness). Overall, the primary school-children's awareness of the game was very high. Approximately 66.5% of

children recalled the BTS game unprompted, while 97.1% had prompted awareness of the game (see figure 4.7). There was no difference in awareness between intervention and control schools. However, a greater proportion of females than males could recall BTS unprompted (71.2% vs 59.8%), although the difference was not significant (see figure 4.8). Overall, the unprompted awareness among secondary school-children reached almost 50% while prompted awareness of the BTS game was as high as 78.3% (see figure 4.9). A greater proportion of females than males could recall BTS unprompted (53.8% vs 46.3%) and prompted (80.7% vs 76.7%), although the difference was not significant (p>0.005).

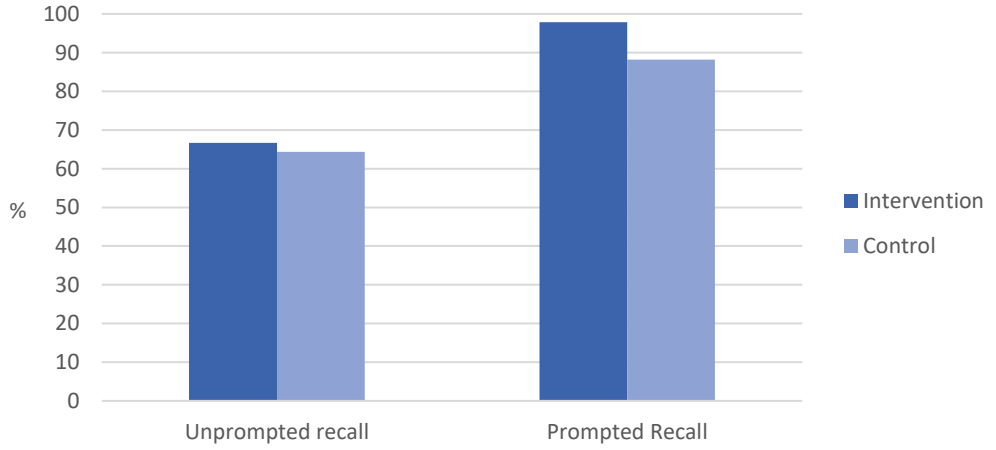

Figure 4.7. Unprompted and prompted awareness of the intervention in primary school-children

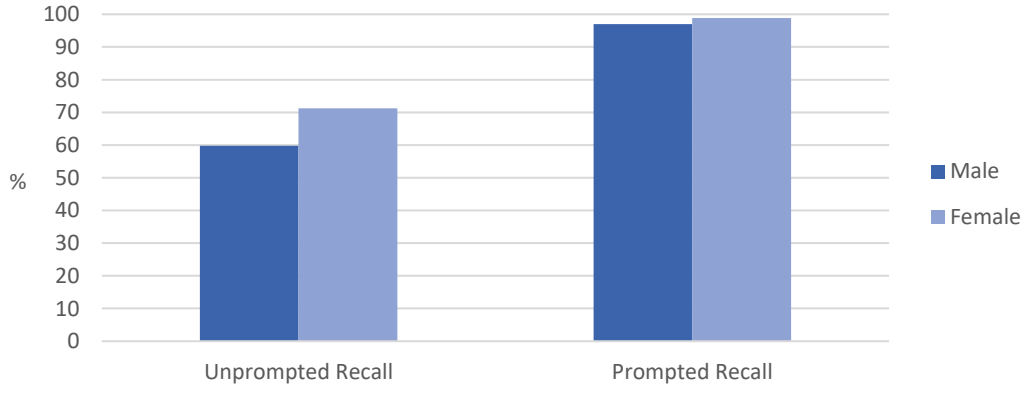

Figure 4.8. Unprompted and prompted awareness of the intervention between males and females in intervention schools

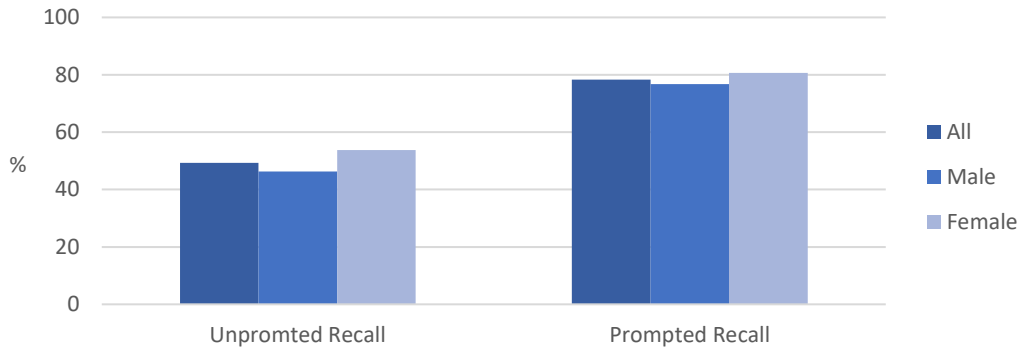

Figure 4.9. Unprompted and prompted awareness of the intervention in secondary school-children by sex

4.4 What impact did BTS have on active travel to school?

There was no overall change in the proportion of primary school-children who walked or cycled to school in the intervention schools compared with control at follow-up. Concurrently, there was no change in the proportion of children who travelled to school by car or bus (see table 4.3). There was, however, a 5.3% increase (NS) in the proportion of school-children that walked home from school post-intervention in intervention schools compared with control schools. This difference was more pronounced for females. There was an 8.8% increase (33.1% at baseline and 36.3% at follow-up; NS) in walking home from school among females compared with a 2.9% decrease (31.3% at baseline, and 30.4% at a follow-up) for males (see Appendix R). Finally, there was no overall change in the preferred mode of travel to school among primary school-children (see table 4.3), yet there was an increase in preference for travelling to school by bus (0.0% vs 4.2%; $p<0.05$) in control schools. Actual and preferred mode of travel to school (and actual travel home from school) at follow-up are available to see in Appendix S.

Table 4.3. The actual mode of travel TO and FROM school and preferred mode of travel TO school pre-and post-BTS in intervention and control schools

	Intervention				Control				Absolute change Difference in differences % (95% CI)
	PRE (%)	POST (%)	% Diff	95% CI	PRE (%)	POST (%)	% Diff	95% CI	
Actual travel TO school									
Walk	24.8	25.3	0.5	-3.0, 4.2	43.7	39	-4.7	-17.8, 8.4	5.3 (-8.3, 18.8)
Cycle	1.7	0.6	-1.1	-2.0, -0.2	1.7	4	2.3	-2.2, 6.8	-3.4 (-8.0, 1.1)
Car	69.3	70.2	0.9	-2.9, 4.7	48.7	47	-1.7	-15.0, 11.5	2.7 (-11.2, 16.5)
Bus	4.2	3.8	-0.4	-2.0, 1.2	5.9	10	4.1	-3.1, 11.4	-4.5 (-11.9, 2.9)
Actual travel FROM school									
Walk	32.3	34.1	1.7	-2.1, 5.6	52.5	40	-12.5	-25.5, 0.6	14.2 (0.6, 27.8)
Cycle	1.4	0.7	-0.7	-1.6, 0.1	1.6	5	3.4	-1.5, 8.2	-4.1 (-9.0, 0.8)
Car	58.8	59.0	0.2	-3.8, 4.3	37.7	41	3.3	-9.6, 16.2	-3.0 (-16.6, 10.5)
Bus	7.5	6.2	-1.3	-3.3, 0.8	8.2	14	5.8	-2.6, 14.2	-7.1 (-15.7, 1.6)
Preferred travel TO school									
Walk	35.2	32.1	-3.0	-6.9, 0.9	41	36.5	4.5	-18.0, 9.0	1.5 (-12.6, 15.5)
Cycle	34.2	33.1	-1.1	-5.1, 2.8	54.3	54.2	-0.1	-13.9, 13.2	-1.0 (-15.4, 13.3)
Car	23.9	31.4	7.5	-3.8, 11.2	4.8	5.2	0.5	-5.6, 6.5	7.1 (0.0, 14.2)
Bus	6.7	3.3	-3.4	-5.2, -1.5	0.0	4.2	4.2	0.2, 8.2	-7.5 (-11.9, -3.1)

As was the case in the primary school sample, there was no overall increase in the proportion of secondary school-children who walked or cycled to school at follow-up (see table 4.4). The proportion that walked or cycled to school decreased from 21.1% at baseline to 19.2% at follow-up. Car travel remained the most dominant mode of travel to school at baseline and follow-up (67% and 68.5%, respectively). The more noticeable decline in AT was evident on the way home from school. At follow-up, AT from school decreased from 28.2% to 23.8%. There was, however, an almost six percentage point increase ($p>0.05$) in the proportion of school-children that would prefer to cycle to school post-intervention (from 17.6% at baseline to 23.6% at follow-up). Concurrently, there was a decline in preference for travelling to school by car (50.2% at baseline, and 45.9% at follow-up; $p>0.05$).

Table 4.4.The actual mode of travel TO and FROM school and preferred mode of travel TO school pre- and post-BTS

	PRE (%)	POST (%)	Absolute % change (95% CI)
Actual travel TO school			
Walk	20.4	18.3	-2.14 (-6.99, 2.71)
Cycle	0.7	0.9	0.18 (-0.91, 1.28)
Car	67.0	68.5	1.49 (-4.26, 7.24)
Bus	11.9	12.3	0.47 (-3.55, 4.49)
Actual travel FROM school			
Walk	27.5	23.0	-4.54 (-9.88, 0.81)
Cycle	0.7	1.1	0.42 (-0.77, 1.610
Car	59.8	61.6	1.85 (-4.18, 7.88)
Bus	12.0	14.3	2.26 (-1.93, 6.46)
Preferred travel TO school			
Walk	21.9	18.6	-3.30 (-8.19, 1.58)
Cycle	17.6	23.6	5.96 (1.00, 10.91)*
Car	50.2	45.9	-4.28 (-10.37, 1.81)
Bus	10.3	11.9	1.63 (-2.21, 5.48)

**p<0.05*

4.5 What impact did BTS have on PA in school-children?

There was no overall change in the number of days primary school-children achieved 60 minutes of MVPA at follow-up in the intervention versus control schools (see figure 4.10). The average number of days that children in the intervention schools achieved 60 minutes of MVPA decreased from 5.5 (±1.72) to 5.2 (±1.82) days. Likewise, in control schools, a number of days on which children were meeting the recommendations for MVPA, decreased from 5.9 (±1.49) to 5.5 (±1.85) days. Furthermore, the proportion of children in intervention schools meeting the PA recommendations decreased from 43.5% to 34.8% post-BTS (figure 4.11; absolute change -8.66%, CI -12.6, -4.7). Likewise, in control school, the proportion of children reaching the recommended MVPA per day dropped from 54.2% to 43% (absolute change -20.6%). Neither of these decreases was statistically significant.
Predictably, secondary school-children had lower levels of MVPA than primary school-children. At follow-up, secondary school-children achieved 60 minutes of MVPA on only 4.5 (±1.91) days per week (see figure 4.12). There was no increase in the mean number of days that secondary school-children achieved 60 minutes of MVPA at follow-up (figure 4.12). The average number of days that school-children achieved 60 minutes of MVPA decreased from 4.8 (±1.88) to 4.5 (±1.90). The proportion of children meeting the PA guidelines decreased from 25.6% to 21.9% at follow-up (figure 4.13; absolute change -3.67%, CI -8.81, 1.47). Neither of these decreases were statistically significant, and there were no differences by sex found. Nevertheless, this result is higher than the 12% reported in a previous Irish study of children in secondary schools (age range 12-18 years; Woods et al., 2010).

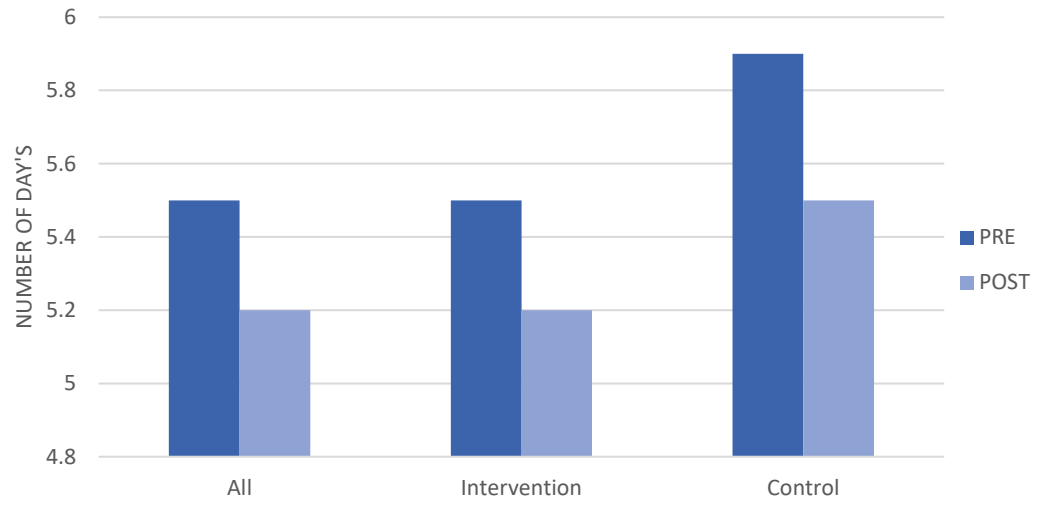

Figure 4.10. Number of day's primary school-children achieved 60 minutes of MVPA pre and post-intervention for total sample and intervention, control schools

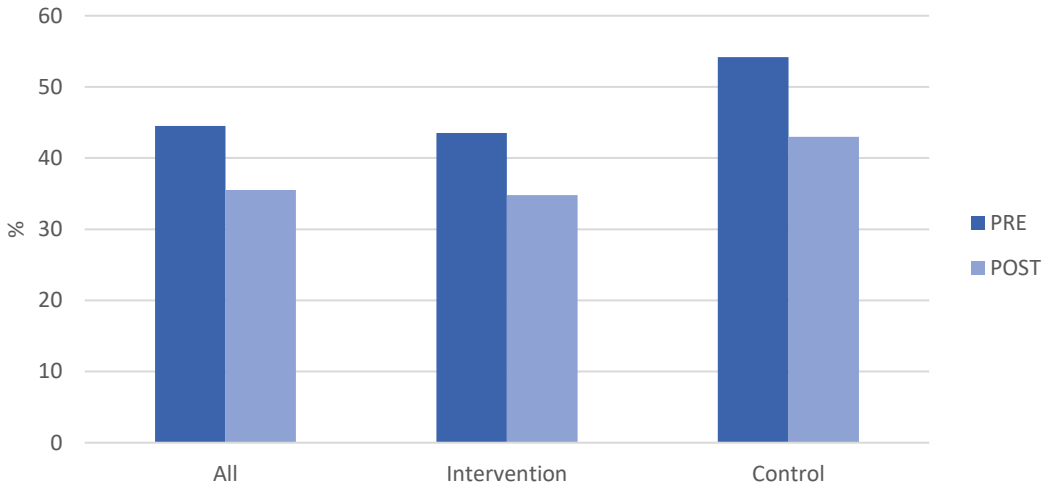

Figure 4.11.The proportion of primary school-children that reached the physical activity recommendations pre and post-intervention

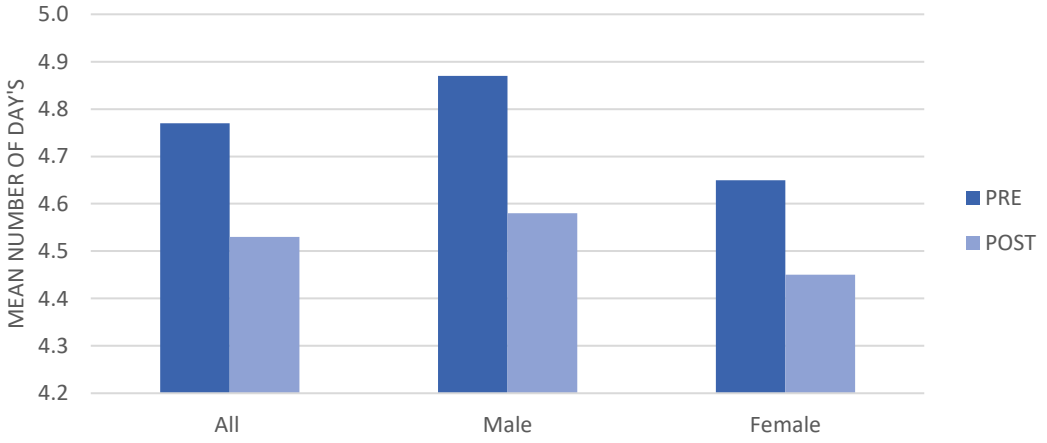

Figure 4.12. Number of day's secondary school-children achieved 60 minutes of MVPA pre and post-intervention by sex

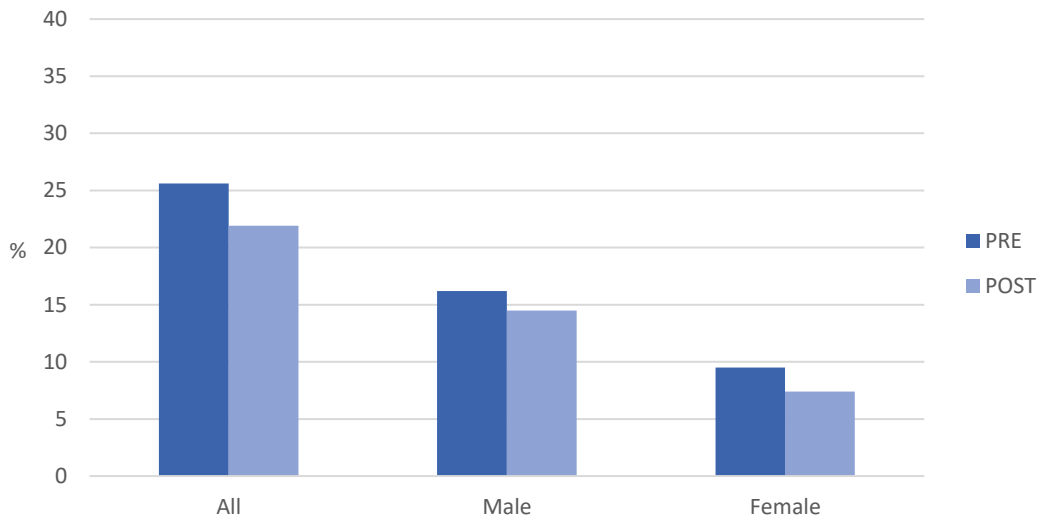

Figure 4.13.The proportion of secondary school-children that reached the physical activity recommendations pre and post-intervention by sex

Almost 43% of primary school-children reported that they visited a new place while playing BTS, and almost 70% expressed a desire to go back there in the future (see figure 4.14). Most of the new places were other streets in Waterford City (52.9%). Nevertheless, 38.4% were placed conducive to PA, such as parks (see figure 4.15). Notably, 31.2% (n=94) of those that travelled to a new place while playing BTS visited the Waterford Greenway for the first time. This proportion represents a total of 7.9% of all participants that visited the Greenway for the first time while playing BTS. There were five factors that predicted the achievement of 60 minutes of MVPA a day in a primary school sample. These were sex, journey time to school, being allowed to cycle to school independently, owning a bike and the frequency of playing BTS. Females were less likely to achieve the recommended levels of PA (OR 0.7 CI 0.561, 0.952; $p<0.05$). Children who were allowed to cycle independently to school were almost twice as likely to meet the guidelines (OR 1.9 CI 1.322, 2.664; $p<0.001$). Likewise, children who owned a bicycle were 1.8 times more likely to meet the guidelines than those who did not (CI 1.240, 2.739; $p<0.005$). Participants who lived up to 15 minutes from their school were over twice as likely to meet the guidelines compared with participants who lived 30 minutes or more from their school (CI 3.571, 1.211; $p<0.05$). Finally, children who played the game every day or several times a week were more than

twice as likely (CI 1.419, 3.456; p<0.001) to meet the guidelines than children who never played the game.

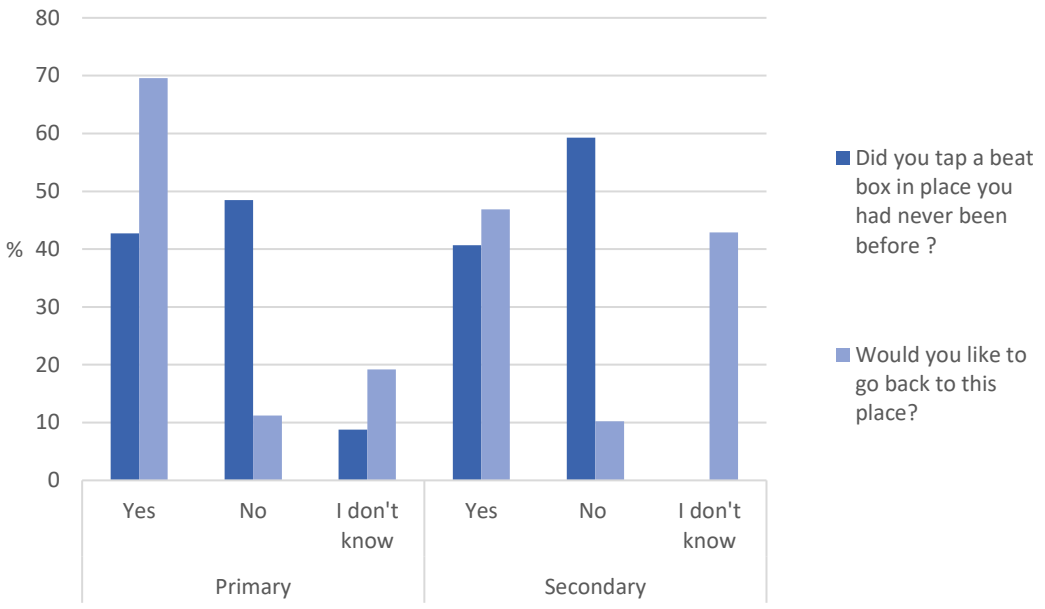

Figure 4.14. The proportion of primary and secondary school-children that tapped a BTS box in a new place and expressed a desire to return there

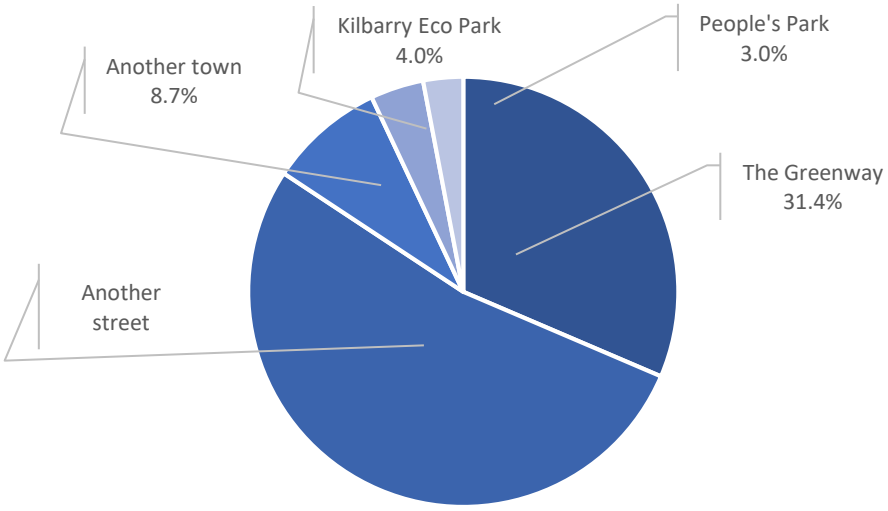

Figure 4.15. The new places primary school-children visited while playing BTS (n=299)

Figure 4.16 below, shows that almost 41% of secondary school-children reported that they visited a new place while playing BTS, and almost 47% of these expressed a desire to go back there in the future. Figure 4.17 shows the type of new places secondary school-children visited while playing BTS. These places were categorised as; other streets in Waterford City (63%), the Greenway (34%) and other towns (3%). Approximately 9% of all participants visited the Greenway for the first time while playing BTS. There were no correlates of meeting the MVPA guidelines in secondary school-children that reached significance.

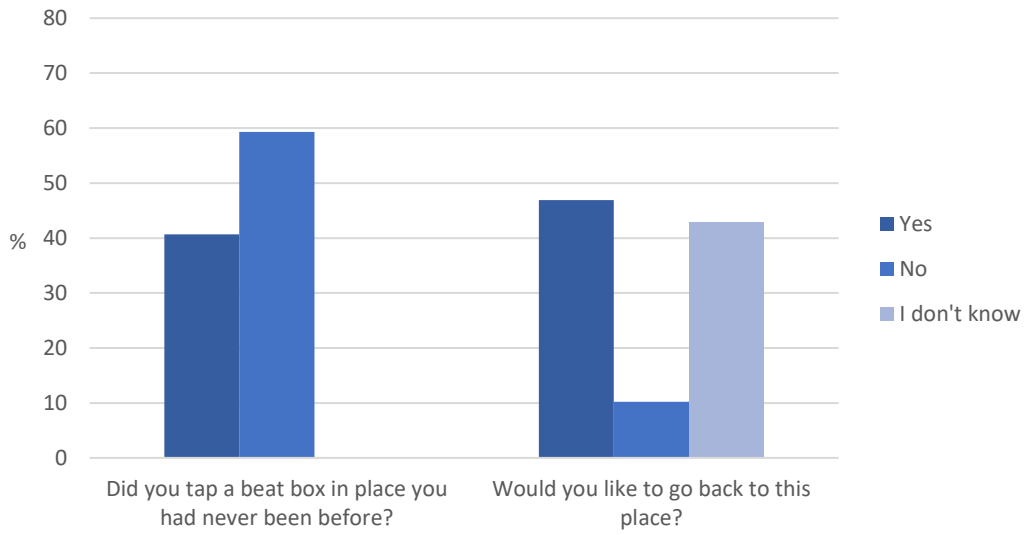

Figure 4.16. The proportion of secondary school-children that tapped a BTS box in a new place, and expressed a desire to return there

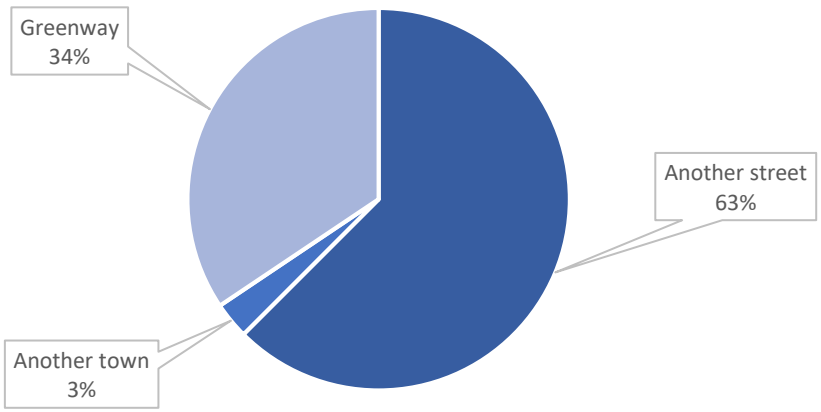

Figure 4.17. The new places secondary school-children visited while playing BTS (n=120)

4.6 What are the factors that influence active travel to school among school-children?

The correlates of ATS are listed in table 4.5 (for primary children) and 4.6 (for secondary children) below. Among primary school-children, there were seven factors significantly correlated with walking and cycling to school: sex, journey time to school, independent mobility, preference for AT, number of cars in the household, owning a bike and the frequency of playing BTS. The strongest predictors of ATS were being granted independent mobility and not having any cars in the household (see table 4.5). Children who travelled to school without adult supervision were over 23 times (CI 13.954, 38.573; $p<0.001$) more likely to do so by walking or cycling than those who were accompanied by an adult. Children living in a household without access to a car were 11.7 times more likely to walk or cycle to school compared with those living in a house with three or more cars (CI 3.468, 39.438; $p<0.001$).

Findings showed that as the journey time to school increased, ATS tended to decline. Children who lived within 15 minutes of their school were 3.8 times (CI 1.258, 11.206; $p<0.05$) more likely to walk or cycle to school when compared with those who lived more than half an hour away. Personal preferences appear to be another strong predictor of ATS. Children who preferred AT were almost 3.9 times (CI 2.327, 6.446; $p<0.001$) more likely to walk or cycle to school than those who preferred passive travel (car and bus). Children that owned a bicycle were 2 times (CI 3.484, 1.160; $p<0.05$) more likely to travel actively to school compared to children who did not own a bike. Children who were aware of the game taking place were 2.3 times (CI 0.095, 53.926; $p>0.05$) more likely to walk or cycle to school than those who were not aware of the game. Similarly, children who played the game every day or several times a week were 2.6 times (CI 1.229, 5.379; $p<0.05$) more likely to walk or cycle to school than those who never played the game.

Table 4.5. Correlates of active travel to school among primary school-children

Variable		OR	95% CI	P value
Sex				
	Male	1	Ref	N/A
	Female	1.5	0.963, 2.470	0.071
Age		0.6	0.427, 0.796	0.001**
Journey time to school				
	≥31 min	1	Ref	N/A
	0 to 15 min	3.8	1.258, 11.206	0.018*
	16 min to 30	1.7	0.493, 5.739	0.407
Independent Mobility				
	Not Granted	1	Ref	N/A
	Granted	23.2	13.954, 38.573	0.000**
The preferred mode of travel to school				
	Passive	1	Ref	N/A
	Active	3.9	2.327, 6.446	0.000**
No. of cars in the household				
	Three and more	1	Ref	N/A
	None	11.7	3.468, 39.438	0.000**
	One	2.0	0.911, 4.496	0.083
	Two	1.4[a]	3.236, 0.640[a]	0.379
Own bicycle				
	No	1	Ref	N/A
	Yes	2.0[a]	3.484, 1.160[a]	0.013*
Meets PA Guidelines				
	No	1	Ref	N/A
	Yes	1.3	0.837, 2.079	0.233
Aware of BTS				
	No	1	Ref	N/A
	Yes	2.3	0.095, 53.926	0.614
The frequency of play the BTS				
	Never	1	Ref	N/A
	Frequently	2.6	1.229, 5.379	0.012*
	Not Frequently	1.3	0.65, 2.801	0.422

[a] Values less than 1 were inverted (1 divided by the original value less than 1) to ease the interpretation
**p<0.05, **p<0.001*

In secondary school-children there were four factors significantly correlated with walking and cycling to school: sex, car driving not perceived as an automatic behaviour, preference for AT and awareness of BTS (see table 4.6). The strongest predictor of ATS was children's preference for AT. Children who preferred to walk or cycle to school were over 38 times (CI 4.449, 328.428; p<0.001) more likely to actively travel to a school than those who preferred passive travel (car and bus). Findings showed that children who disagreed with the statement that 'car travel to school is something that I

do automatically' were almost 17 times (CI 71.429, 3.968; p<0.001) more likely to walk or cycle to school when compared with children who agreed with the statement. Secondary school-children who were aware of BTS taking place were 11 times (CI 66.667, 1.88; p<0.05) more likely to walk or cycle to school than those who were not aware of the game. Females were 4.7 times (CI 0.998, 21.659; p<0.05) more likely to travel by active means of travel to school when compared with males. Not having any cars in the household was another strong predictor of AT. Children living in a household without access to a car were 16 times (CI 0.875, 292.009; p>0.05) more likely to travel actively to school. While not statistically significant, the home-school distance may also influence the mode of travel to school. Findings showed that as the journey distance to school increased, ATS declined. As shown in table 4.6 below, children who lived within 1.5 km of their school were 3.2 (CI 0.303, 34.062; p>0.05) times more likely to choose active means of travel than children who lived more than 3 km away.

Table 4.6. Correlates of active travel to school among secondary school-children

Variable	OR	95% CI	P value
Sex			
Male	1	Ref	N/A
Female	4.7	0.998, 21.659	0.050*
Age	0.5	0.134, 1.632	0.233
Proximity from home to school			
>3km	1	Ref	N/A
1.5-3km			
<1.5km	3.2	0.303, 34.062	0.332
No. of cars in the household			
Three and more	1	Ref	N/A
None	16.0	0.875, 292.009	0.061
One	0.9	0.081, 9.569	0.916
Two	0.2	0.021, 2.772	0.254
Meets PA Guidelines			
No	1	Ref	N/A
Yes	2.8	0.668, 11.496	0.161
Own bicycle			
No	1	Ref	N/A
Yes	3.6[a]	41.667, 0.318[a]	0.299
Allowed to cycle			
No	1	Ref	N/A
Yes	3.8	0.408, 35.728	0.24
Car driving is automatic			
No	16.9[a]	71.429, 3.968[a]	0.000**
Yes	1	Ref	N/A
The preferred mode of travel to school			
Passive	1	Ref	N/A
Active	38.2	4.449 , 328.428	0.001**
Awareness of BTS			
No	1	Ref	N/A
Yes	11.1[a]	66.667, 1.883[a]	0.008*
The frequency of play BTS			
Never	1	Ref	N/A
Not Frequently	1.0	0.107, 8.777	0.978
Frequently	4.3	8.777, 38.954	0.194

[a] *Values less than 1 were inverted (1 divided by the original value less than 1) to ease the interpretation*

**p<0.05, **p<0.001*

4.6.1 Independent mobility on the journey to school and parental trip chaining

Note: This section presents the proportion of primary and secondary school-children allowed to walk or cycle to school on their own. Secondary school questionnaire was supplemented with an additional question regarding parental trip chaining, and the results are presented here as well.

The majority of children in the total sample did not have independent mobility on the journey to school at baseline or follow-up (59% and 72.6% respectively; NS; see figure 4.18). That is to say, the majority of primary school-children were accompanied by an adult on the way to school at both time points, and independent mobility decreased over the year. At both time points, the proportion of children being granted independent mobility was greater in control schools than intervention schools (61% vs 38.9%, $p<0.05$ at baseline, and 52.5% vs 25.3%, $p<0.005$ at follow-up; see figure 4.18). Furthermore, there was a gender difference in independent mobility at both time points. At baseline, 42.8% of males had independent mobility in comparison with 34.8% of females (NS, see figure 4.19). At follow-up, 39.5% of males had independent mobility compared with only 22.4% of females ($p<0.05$). Finally, only 47.3% and 33.2% of children were allowed to walk or cycle to school on their own at baseline (respectively), and 46.4% and 34% at follow-up. At both time points, there was a greater proportion of males than females allowed to cycle to school independently (45.4% vs 26% at baseline, and 43.4% vs 24.7% at follow-up; $p<0.05$).

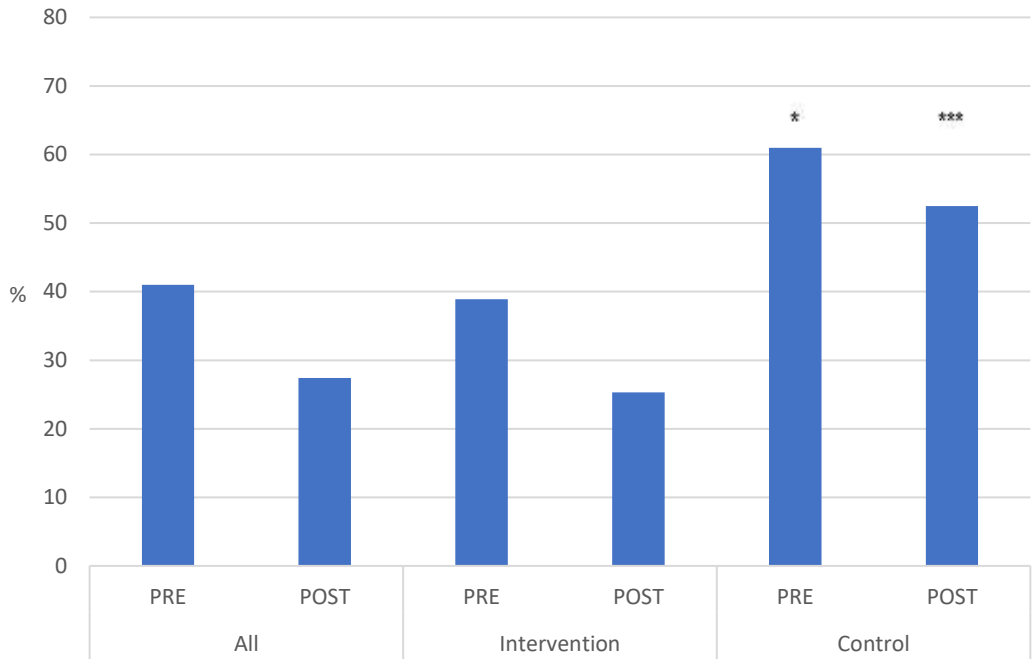

Figure 4.18. Independent mobility on the journey to school at baseline and follow-up for the total sample; intervention and control schools
**p<0.05, ***p<0.05*

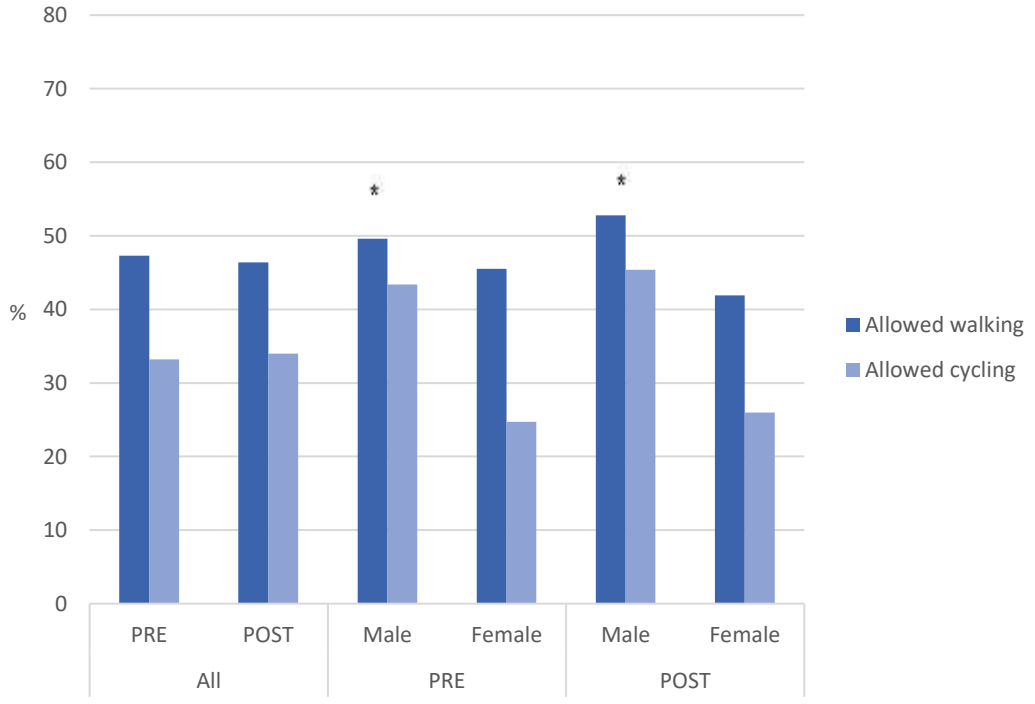

Figure 4.19. The proportion of primary school-children allowed to walk or cycle to school on their own
**p<0.05*

4.6.2 Distance and travel to and from school

Overall, almost 70% of secondary school-children reported living greater than 3km from their school (see figure 4.20). Only 7.7% of the sample stated that they lived within 1.5km. A further 23.1% stated they lived between 1.5km and 3km of their school.

Figure 4.21 below shows the proportion of secondary school-children at follow-up who actively travelled to school according to the distance they lived from their school. Active travel was most prevalent among those living in the closest proximity of their school (>1.5km) and tended to decline with increased distance (1.5-3km and >3km). Over 58% of secondary school-children who lived within 1.5km of their school walked or cycled to school. That proportion decreased to 28.6% ($p<0.001$) and 8.5% ($p<0.001$) for those living between 1.5km and 3km, and more than 3km from school, respectively.

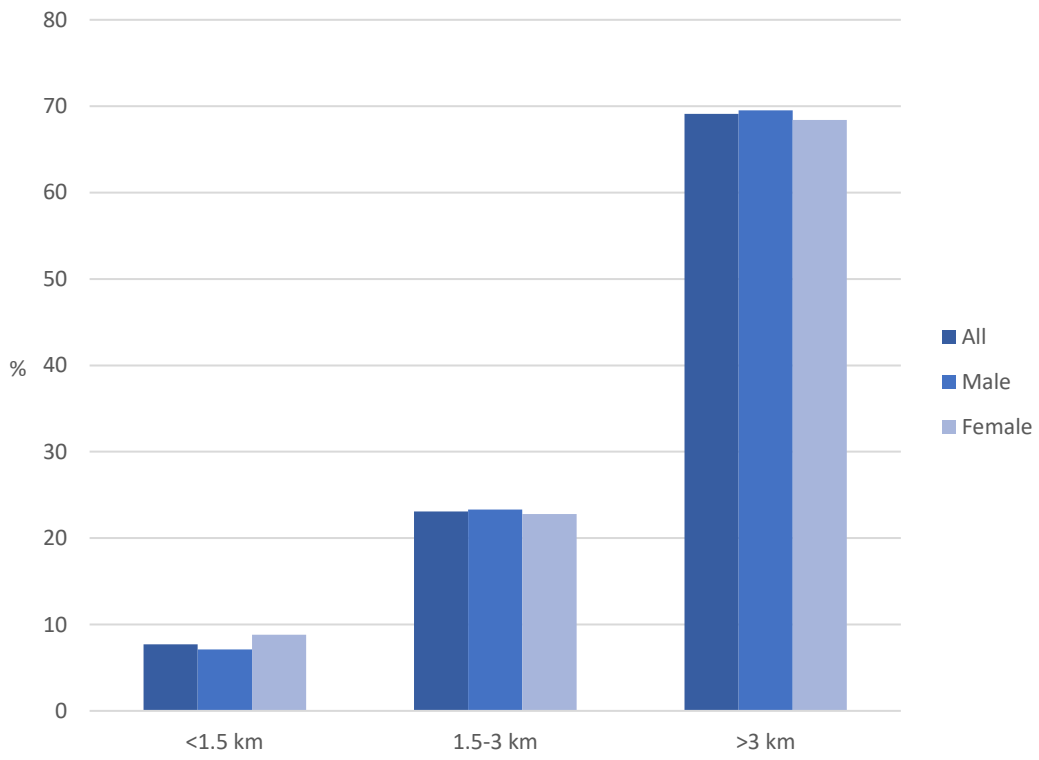

Figure 4.20. The proportion of secondary school-children living less than 1.5km, 1.5-3km, and more than 3km from their school

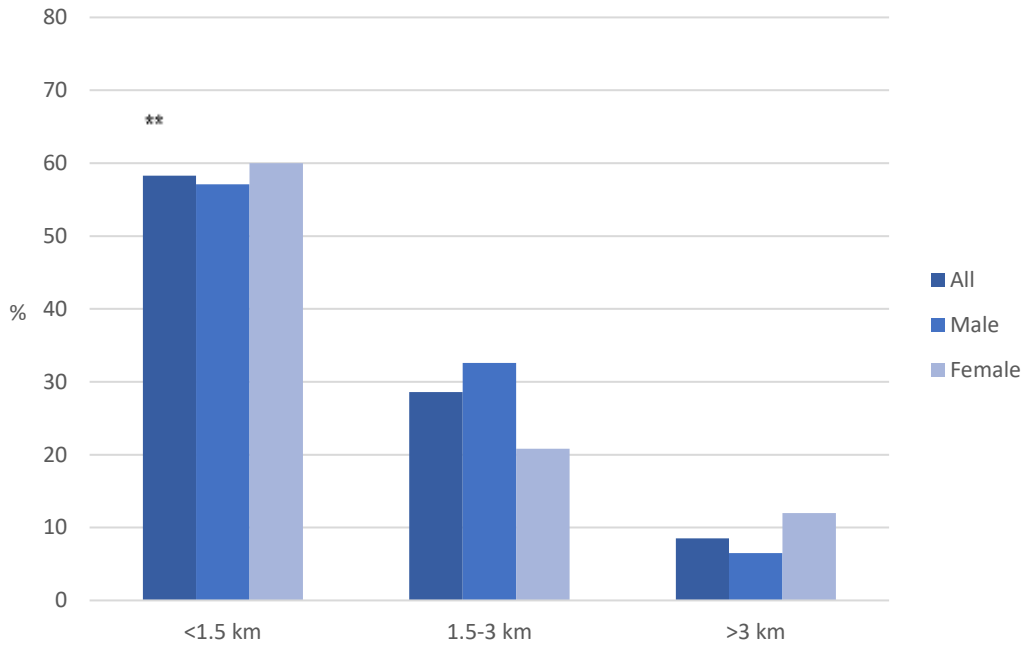

Figure 4.21. The prevalence of active travel to school according to the perceived home-school distance at follow-up

In secondary schools, almost 62% of children had some level of independent mobility. Although not significant (p>0.05), a greater proportion of males than females (63.9% vs 58.2%) declared they were independently mobile (see figure 4.22). Figure 4.23 below shows the proportion of children with independent mobility in relation to the perceived home-school distance. Among those who lived beyond 3km of their school, over 64% reported being independently mobile. Among children who lived closer to school (1.5km-3km), almost 70% of children reported being independently mobile. Unusually, only 44% of children who lived closest to their school, (less than 1.5km) reported having independent mobility (44%; see figure 4.23).
The secondary school questionnaire also included a question regarding parental trip chaining for children who were driven to school by car. Overall, 71% of children who travelled to school by car, reported that their parents were travelling somewhere else after dropping them off as opposed to just returning home (see figure 4.24).

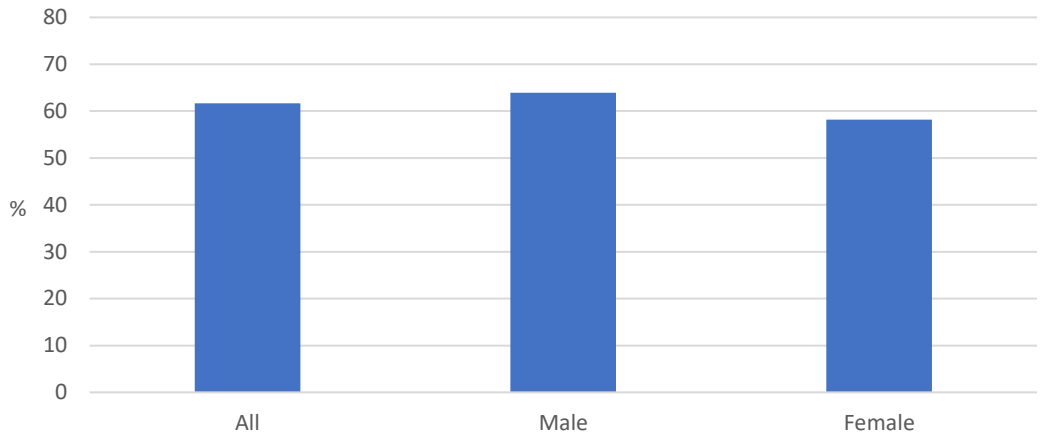

Figure 4.22. The proportion of secondary school-children granted independent mobility by sex

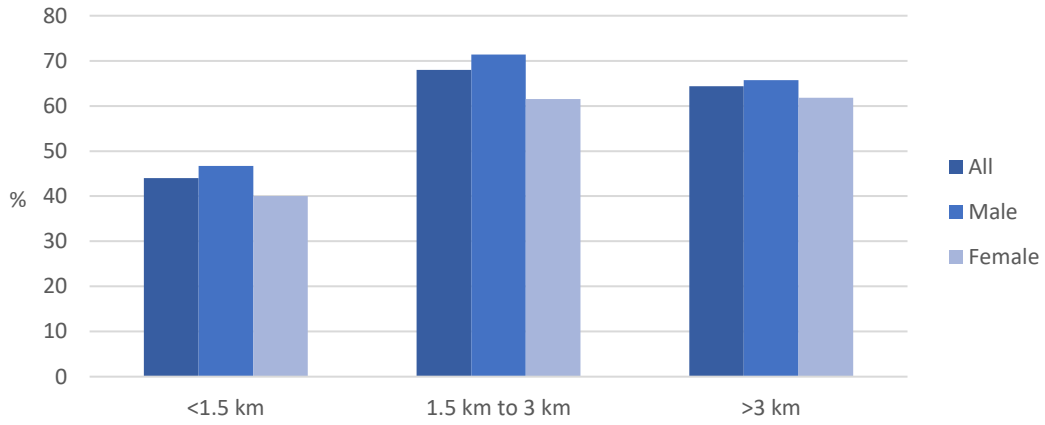

Figure 4.23. Independent mobility in secondary school-children in relation to the home-school distance by sex

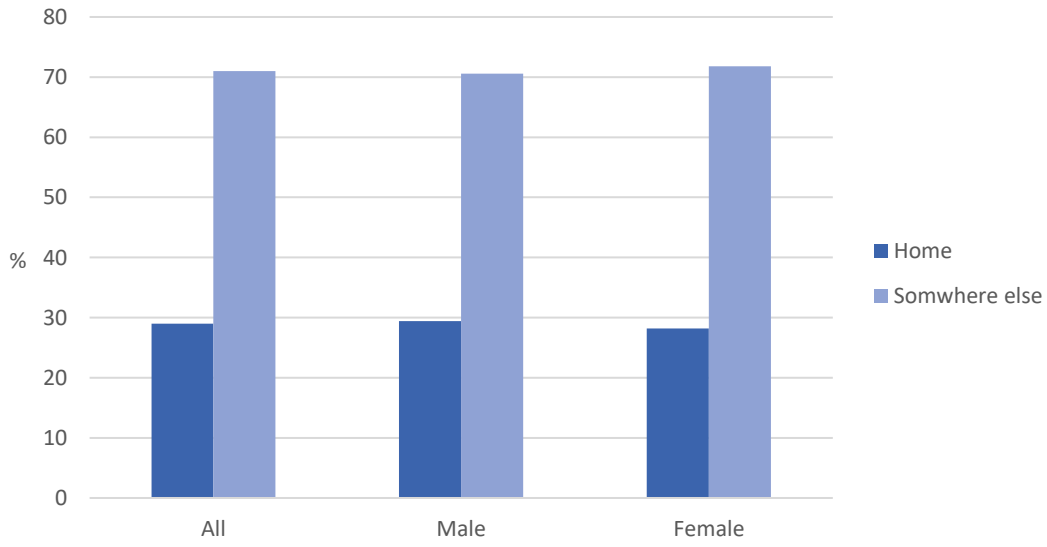

Figure 4.24. Where parents went after dropping their children to school

4.7 What did school-children perceive to be the strengths and weakness BTS?

Participating children were asked about the things they enjoyed most about playing BTS (see figures 4.25 and 4.26). Overall, the features of the game primary school-children enjoyed the most were: collecting points (37.6%), spending time outdoors (30.1%), walking more (27.1%), and spending time with friends (25.9%). The general competitiveness of the game (23.9%) was another important reason for playing the game. Notably, females were more likely than males to provide multiple reasons for enjoying the game, possibly indicating that females enjoyed the game to a greater extent.

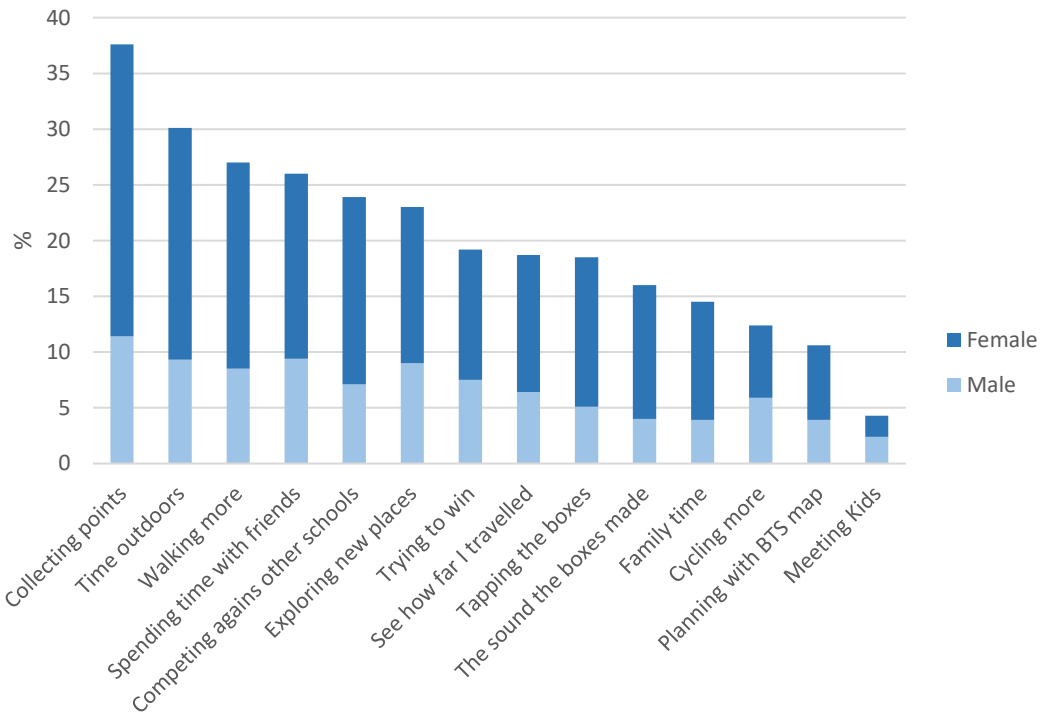

Figure 4.25. Things that primary school-children enjoyed about BTS

The things secondary school-children enjoyed most about the game were spending more time with friends (38.9%), collecting points (37.3%), and winning prizes (36.5%; see figure 4.26). Males were more likely than females to state that they enjoyed planning their journeys with the BTS map ($p<0.001$).

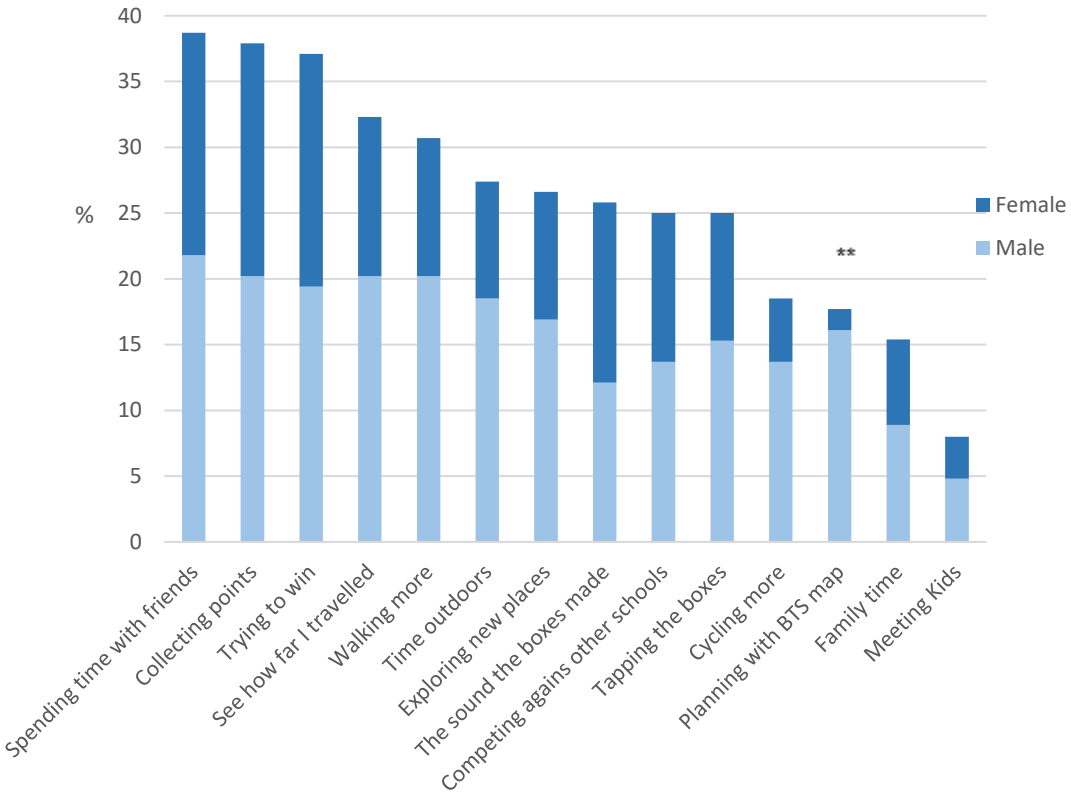

Figure 4.26. Things that secondary school-children enjoyed about BTS
***p<0.001*

Likewise, children were asked what would improve BTS. The section below shows their recommendations. Overall, a total of 727 primary school-children (56.2% of the total sample) presented their ideas for improvement, and these were further categorised into 26 common themes. A total of 196 secondary school-children (40.6% of the sample) presented their ideas for improvement of BTS, and these were further categorised into 21 common themes. For that reason, these themes are presented separately for primary and secondary schools. Figure 4.27 is a visual representation of primary school recommendations, whereas figure 4.28 represents secondary schools recommendations.

The most recurring theme in both primary and secondary school-children was the idea of having more boxes in more diverse locations. Children suggested that the boxes should be closer together and more boxes should be placed around schools and housing estates. Other suggestions regarding location

included placing more boxes in the countryside and more interesting places such as the Greenway, parks, forests, mountains, and so forth. Another recurring theme was making the game more challenging, fun and interesting. In primary school-children that included secret, hidden locations for boxes, more colourful boxes that would make different sounds. Some children suggested that the time between taps could be decreased to make the game into a race. It was suggested that it should be possible to create small teams within the school and with friends from other schools. Different challenges to gain more points throughout the game would make the game even more appealing. Secondary school-children suggested more game-like components (i.e. levels within the game, the possibility of creating own avatars) and in general ‘less childish’ features.

All school-children strongly suggested a more comprehensive reward system. It was suggested that having a chance to win prizes throughout the game and having an individual prize would motivate children to play the game more often. Primary school-children suggested that prizes would not have to be big to promote the feeling of reward and accomplishment. In turn, secondary school-children suggested vouchers and shop discounts as incentives for accumulating BTS points.

A large number of primary school-children mentioned that they would like to avoid the online registration and to log in online to check information about their position on the leaderboard. They explained that this was difficult and time-consuming. Alternatively, they suggested having a function to see the points on the box after tapping it. Some children, especially at the secondary level, recommended a phone app that would show them acquired points, the leaderboard, the nearest boxes, and the overall map. Primary school-children mentioned that if boxes were numbered as they were on the map, it would make it easier to follow it.

Finally, both primary and secondary school-children suggested that the game would benefit if there were more engagement at the school level. There should be more organised activities to coincide with the game and more promotion of the game itself. Especially secondary school-children expressed their lack of awareness of BTS as they ’never heard of the game’ and ‘didn’t

know enough about the game'. Secondary school children suggested that more BTS cards should have been distributed. Primary school-children recommended that the game could last longer, and take place at another time of year when there is more daylight. Some primary school-children were aware of people driving to the boxes and indicated their frustration with this cheating. They believed that there should be a way of differentiating between modes of travel to stop this.

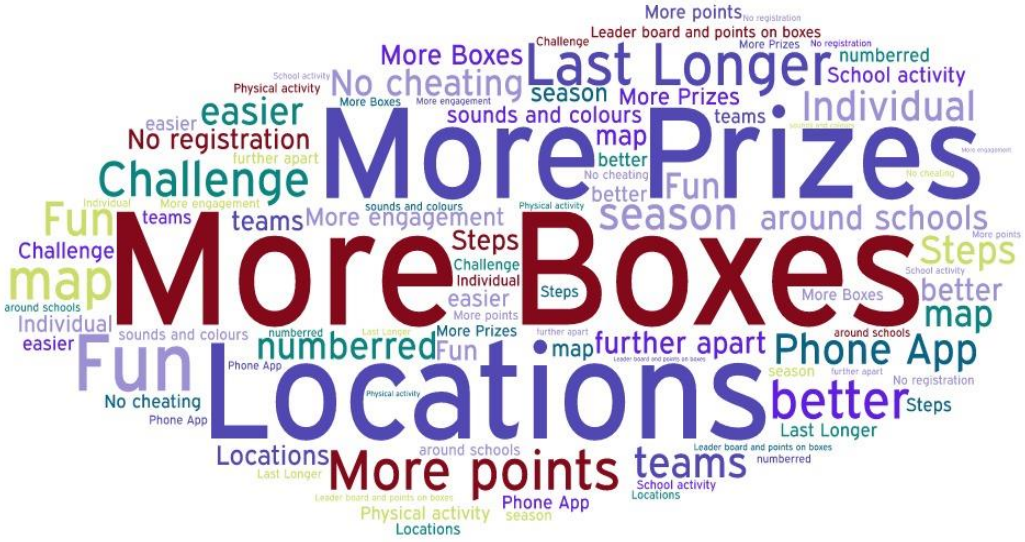

Figure 4.27. Word frequency of recommendations to improve BTS according to primary school-children

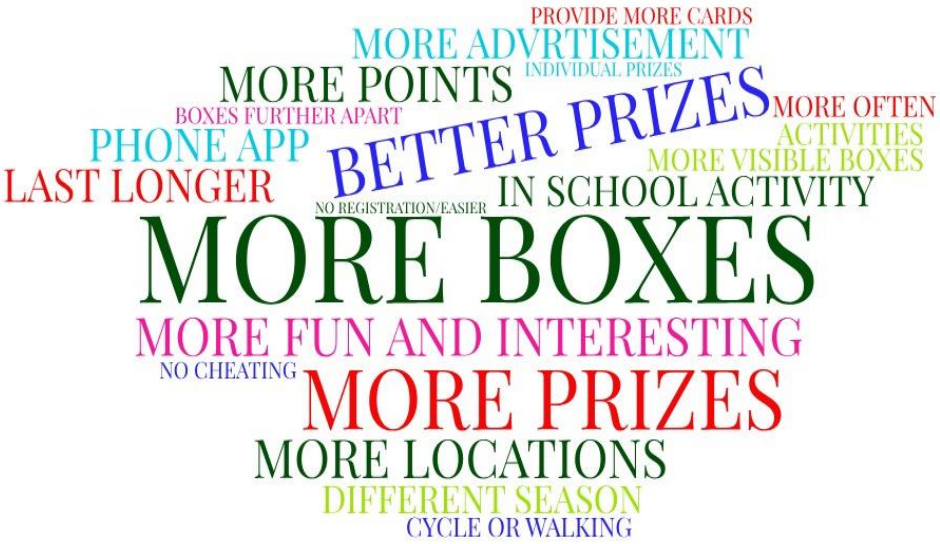

Figure 4.28. Word frequency of recommendations to improve BTS according to secondary school-children

5 Discussion

5.1 Summary of the Findings

Primary school data was collected from 1289 children from eighteen schools at baseline and 1293 children in the same schools at follow-up. Overall, children's awareness of the game was very high (97.1% prompted and 66.5% unprompted).

The secondary school data was collected from 603 children in nine schools at baseline, and 483 children from eight schools at follow-up. The unprompted awareness was almost 50%, whereas prompted awareness was as high as 78.3%. Overall, secondary school-children showed a lower engagement with the game when compared with primary school-children. For instance, 38.3% of secondary school-children claimed they never played the game. This was higher than reported 15.3% for the primary school sample. In primary and secondary schools, females were significantly more likely to play the game regularly when compared to males.

Beat the Street did not increase the proportion of children who walked or cycled to school post-intervention. However, there was a 5.3% increase in the proportion of primary school-children who walked home from school post-intervention. Likewise, there was no increase in the number of day's school-children achieved 60 minutes of MVPA or in the proportion of children meeting the PA recommendations. The correlates of ATS in primary schools were: sex, journey time to school, independent mobility, preference for AT, number of cars in the household, owning a bike, and the frequency of playing the BTS. For MVPA, these correlates were: sex, journey time to school, being allowed to cycle to school independently, owning a bike, and the frequency of playing the BTS. It is worth noticing that the majority of primary school-children in the total sample did not have independent mobility on the journey to school at baseline or follow-up (59% and 72.6% respectively). In secondary school sample there were four factors significantly correlated with walking and cycling to school: sex, car driving not perceived as an automatic behaviour, preference for AT, and awareness of BTS. However, there were found no correlates of meeting the MVPA guidelines in secondary school-children that reached significance.

5.2 Discussion of the Findings

5.2.1 The potential for an intervention effect

Although there was no apparent intervention effect detected for PA in primary and secondary school-children, some positive results were found. A large proportion of primary and secondary school-children reported that they visited a new place while playing BTS, and most of them expressed a desire to go back there in the future. It is noteworthy that these places were conducive to PA (Greenway, parks). It is plausible that these children might be more inclined to be physically active in the future. Likewise, primary school-children who played the BTS game every day or several times a week were more than twice as likely to meet the guidelines as children who never played the game. The same association was found for secondary school-children, but not as significant.

There was some small-to-modest effect for ATS. For instance, secondary school-children who played the game regularly were eight times more likely to walk or cycle to school compared with those who never played the game. In turn, primary school-children who played the game regularly were almost three times more likely to choose active modes of travel compared with children who never played BTS. Furthermore, there was a trend towards an increase in the proportion of females in primary schools that walked or cycled home from school. Findings showed that post-BTS, the proportion of females walking home from school increased by as much as 8.8% increase (33.1% at baseline and 36.3% at follow-up). These findings are consistent with previous evaluations of BTS. According to Combes and Jones (2016), BTS did not increase PA in intervention schools. However, there was an observed increase in ATS of approximately 10%. Authors equated that to one additional active journey per child per week. Hunter et al., (2015), found that the proportion of children walking at least once a week to school increased from 77% at baseline to 86% at follow-up. Correspondingly, 59% of children stated they walked more by the end of the competition period.

It is plausible that the outcome measures adopted within this evaluation did not consider all possible positive results of this intervention. It is likely that there were benefits of playing the game beyond PA and AT. For instance, the

things primary school-children enjoyed most about the game were spending time outdoors (30.1%), walking more (27.1%), and spending time with friends (25.9%). Similarly, secondary school-children appreciated socialising more with friends (38.9%). This is a valuable observation as it shows what drives children to engage with interventions like BTS and what motivates them to play these game. Correspondingly, Rutberg and Lindqvist (2018) reported that gamified interventions promoting ATS are capable of creating a sense of togetherness and readiness to learn in children. Likewise, it can improve parental attitudes towards AT. Wong, Turner, MacIntyre, and Yee (2017) found additional positive effects such as increased encouragement for exercise and goal setting for exercise. Perhaps the positive effect of BTS was in giving primary school-children the opportunity of spending more time in the open air, bringing them together, allowing them to build new friendships. It is plausible that BTS built a sense of togetherness in secondary school-children and positively influenced their attitudes towards AT while also increasing parental encouragement for AT.

One of the major strengths of BTS Waterford was the high awareness of the intervention. In primary school-children, 66.5% of children were aware of BTS unprompted, whereas 97.1% were aware of BTS when prompted. In secondary school-children, these proportions were 50% and 78.3%, respectively. The high levels of awareness were possibly due to a comprehensive mass media campaign. As shown in the literature, health messages can be successfully marketed to children and bring positive results by applying the same marketing strategies that are used to sell products to children (Huhman et al., 2010). Moreover, Huhman et al. (2010) suggested that the effects of a media campaign targeting young children may continue through their adolescent years. It is plausible that the BTS intervention may resonate in later years in children who were actively engaged in the game.

5.2.2 The factors that mitigated against detecting an intervention effect

The lack of an intervention effect for PA and a more substantial effect for AT is not uncommon in the available literature. Evidence from systematic reviews shows that interventions related to AT and PA in school-children have produced only small to modest effects (Larouche, Mammen, Rowe, & Faulkner, 2018; Camacho-Minano, Lavoi & Barr-Anderson, 2011; Metcalf, Henley, & Wilkin, 2012). The lack of an intervention effect in this study can be explained by several factors, as described below.

5.2.2.1 Engagement with BTS

Considering the population targeted and the duration of the intervention, the levels of overall engagement with the game can be classified as low (approx. 10.5% of the population[5]). By contrast, BTS Caversham was able to engage 30,000 participants (approx. 20%) of the population (Bird, 2014). Correspondingly, participation in BTS Waterford was substantial during the first two weeks but gradually declined as the game progressed. Over half of the taps took place in the first two weeks of the game, and only 4.6% of taps took place in the final week of the game. This is consistent with findings from other gamified interventions and previous evaluations of BTS (Howe et al. 2016; Garde et al., 2018; Hunter et al., 2015; Coombes & Jones, 2016). For instance, Howe et al. (2016) who looked at the effects of Pokémon GO on PA in young adults, reported that, in the intervention group, the number of daily steps increased significantly (955 steps; $p<0.05$) in week one before gradually returning to baseline levels. The number of daily steps in the control group remained at similar levels throughout the game. Likewise, Hunter et al. (2015) showed that the average number of children actively commuting to school during BTS progressively declined from 29% in week one to 12% in week four. It is plausible that participants' engagement with gamified interventions may be just short-term as the novelty of the games fades away with time.

[5] Population of Waterford City and County Council in 2016 was 116,176, CSO, 2016

5.2.2.2 The age, gender and independent mobility

The findings from this study would seem to imply that the effect of BTS was influenced by the age and gender of the children. The secondary school-children engaged with BTS to a lesser extent than the primary school-children and in primary schools, males were less engaged than females. A greater proportion of females were also inclined to list several features they enjoyed about the interventions. The higher engagement levels among females may have ultimately increased their likelihood of walking, cycling, and meeting PA recommendations. Several reviews found that in adolescence, there is a decrease in PA participation and active travel, with males more likely to be active and engage in active travel (Sterdt, Liersch & Walter, 2013; Martins et al., 2017; Bauman et al., 2012; Rothman et al., 2017).

Furthermore, according to Coombes and Jones (2016), females tend to be more likely to partake in PA research than males, hence their greater awareness and engagement with BTS. Likewise, Vanwolleghem et al. (2016) highlight how the transition from primary to post-primary school is an important time in children's lives. According to the authors, it is at this time when they may switch modes of travel to school (Vanwolleghem et al., 2016). The authors suggested that future behaviour change programs promoting AT will need to target this transition in life.

The data from this study showed that 27% and 62% of primary and secondary school-children were granted the freedom of independent travel to school, respectively. By contrast, another Irish study by O'Keefe and O'Beirne (2015), showed that only 9.8% and 10.6% of primary school-children could travel independently to and from school, respectively. At the secondary level, 12.7% and 12.2% of children exercised their autonomy in travel to and from school, respectively. This is an important finding because it is challenging to create a modal shift to AT without independent mobility. The data from this study showed that the majority of primary school-children played the game with their parents or another adult. Only 15% of children stated that they played the game on their own. This suggests that children's engagement with BTS and ultimately, the effectiveness of the programme was affected by children's low levels of independent mobility. As was mentioned earlier, parents act as

‘gatekeepers’ to their offspring’s independent travels. It is a socially validated norm, and it is convenient to do so (Egli et al., 2018). Possibly, parental perceptions of road and neighbourhood safety could also have contributed to their unwillingness to allow children to travel to school independently.

5.2.2.3 The persuasive architecture of the game

As mentioned in the literature review, in order for gamified interventions to be successful, they must employ elements called persuasive strategies. These strategies create the persuasive architecture of the game (Cugelman, 2013) and include goal setting, the capacity to overcome challenges, providing feedback on performance, reinforcement of the desirable behaviour, avoiding punishments, comparing progress, social connectivity, and fun and playfulness of the game. Although BTS employed many of these strategies (i.e. leader boards, feedback on performance, rewarding positive behaviour, comparing progress), it is possible they were not compelling enough to reinforce the behaviour change. It is plausible that the lack of ‘flow’ (optimal experience where the user becomes absorbed in the activity that matches his level of expertise; Cugelman 2013) within the game, moderated any positive results of the intervention. Cugelman (2013) stated that, if the game is too easy, participants become bored and stop playing. Findings from this study showed that children desired more challenge, rewards, and fun within the game. It is plausible that if the playfulness of BTS increased as the game progressed, that participants would have a more satisfactory flow experience, resulting in an intervention effect (Cugelman 2013). Another aspect that could have mitigated against detecting an intervention effect is the reward system. It is plausible that the small number of points given for each tap and the lack of individual prizes may not have been compelling enough to engage children with BTS or were not meaningful to them. For instance, results from this study revealed that primary and secondary school-children alike would prefer to have more points per tap and individual prizes, and more opportunities to win incentives. The primary school-children stated that these prizes would not have to be significant, but even small rewards would be appreciated. According to Garde et al., (2018) and Coombes and Jones (2016),

appropriate tactics in gamified interventions, such as a reward system, may lead to the greater effectiveness of this intervention.

5.2.2.4 School and community empowerment

Another aspect that needs to be considered when evaluating the effectiveness of BTS is the location of the boxes. This study showed that the most frequently tapped boxes were located near the city centre, around the schools and recreational areas. Schools located from these areas were potentially at a disadvantage. Nonetheless, as the results of this study showed, that was not the only factor influencing engagement with the intervention. For instance, one of the schools at the top of the leader board (total of 59,850 points) was not located in the city centre and did not have a high density of beat boxes in its vicinity. In contrast, two schools with the lowest average points were located in areas with, arguably, good street connectivity. This suggests that the school's engagement with the game (i.e. BTS-related activities organised by the school) played a vital role too. According to the secondary school results, 57.4% of females played the game with their friends during school hours, indicating that some schools integrated BTS into their curriculum. Likewise, the children's recommendations on how to improve BTS included the addition of organised activities at the school level to coincide with the game. Children suggested that this would increase the frequency of playing the game and further promote it. This would be particularly important at the secondary level as many children stated they 'never heard of the game' and 'did not know enough about the game'. Furthermore, the majority of the taps took place from Monday to Friday during the hours directly before and after school, suggesting that many children played the game on the journey to and from school. This could mean that gamified interventions of this type can be useful in the promotion of ATS rather than for recreation.

Previous qualitative evaluation of BTS showed that schools were not always sure of their role and responsibilities throughout the intervention and perceived parental attitudes as a barrier to children walking or cycling to school (Hunter et al., 2015). It is plausible that there would have been a

greater intervention effect in BTS Waterford if schools and parents had greater involvement in the intervention (Verjans-Janssen et al., 2018; Erwin, Beighle, Carson & Castelli, 2013; Heath et al. 2012; Coombes & Jones, 2016). That could be achieved by providing relevant training programs for school staff on how to help with BTS, the appointment of a BTS champion figure at the school level, possibly from the staff and parent body (Erwin, Beighle, Carson & Castelli, 2013; Heath et al. 2012). Furthermore, it is possible that direct parental involvement within the intervention at the school level would bring more significant intervention results. According to Verjans-Janssen et al., (2018), effective health-promoting programs involve parents directly through organised group sessions, family activities (family cooking nights, activities in the supermarket), and one-on-one support sessions.

5.2.2.5 Intervention Design

An explanation for the lack of an intervention effect could be the intervention design. It cannot be ruled out that the duration of the intervention, which, in this case, was seven weeks, was not long enough to allow a behaviour change. According to Lally, Jaarsveld, Potts, and Wardle (2009), uptake of a new habit depends obviously on the habit itself, but also on the person, and the circumstances. The authors studied participants who chose one new habit for twelve weeks. Participants reported each day on whether or not they performed the behaviour and how automatic it felt. At the end of the twelve weeks, the researchers analysed the data to determine how long it took each person to create a new automatic behaviour and estimated the potential time it takes for this to happen. Results showed that it could take anywhere from 18 days to 254 days for people to form a new habit. Perhaps a longer intervention duration would produce greater intervention effects.
The BTS intervention was focused on increasing PA through AT in a whole community, including different population groups (primary school-children, adolescents and adults). The evidence from systematic reviews that interventions that focused on one behaviour in one specific population group obtained greater intervention effects (Chillón, Evenson, Vaughn & Ward, 2011; Camacho-Minano, Lavoi & Barr-Anderson, 2011; Atkin, Gorely, Biddle,

Cavill & Foster, 2010; Meester, Lenthe, Spittaels, Lien & Bourdeaudhuij, 2009). Overall, studies reporting more significant intervention effects focussed exclusively upon increasing PA or AT whereas a large proportion of less effective interventions had a broader focus (i.e. ATS and PA, weight gain prevention, diet improvements; Chillón, Evenson, Vaughn & Ward, 2011; Atkin, Gorely, Biddle, Cavill & Foster, 2010). Likewise, successful interventions often implemented gender-specific programs that cater to the unique needs of young females (Camacho-Minano, Lavoi and Barr-Anderson, 2011). Given that female's PA levels were lower than males and that females displayed a greater engagement in the BTS Waterford intervention, it may have been more effective if the BTS game was tailored specifically for males and females separately. Moreover, it is plausible that if the BTS intervention focused on changing one behaviour, i.e. ATS and did not try to address both transport and recreational physical activity, it would achieve more significant results.

According to Heath et al. (2012), the key to successful community-focused PA interventions is adopting an intersectoral approach. In an Irish context, this would consist of a collaborative approach to coordinating and implementing physical activity interventions. The key stakeholders would include community and government bodies such as schools, businesses, local sports partnerships, and the local authority. An example of such an approach would be Jackson's 'Safe Routes to School' program that aimed to create a more walkable community and a community that uses more sustainable means of travel (Hendricks, Wilkerson, Vogt and Tenbrink, 2009). The programme engaged representatives from the city engineering department, road commission, health department, schools, local bicycle club, and a variety of other service organisations (Hendricks, Wilkerson, Vogt and Tenbrink, 2009). The programme showed an 8% increase in children who perceived walking to school as safer and the proportion of school-children walking to school more than doubled in the majority of schools. In adults, the intention to try AT increased by 43%, and the proportion of people using AT increased by 63%. This study showed how adopting a multisectoral and collaborative approach can produce positive results in the promotion of AT. In the case of Waterford,

it is possible that greater and more sustainable intervention effects would have been detected had there been a stronger focus on community empowerment and collaboration. Such an approach would be particularly important for sustaining any behaviour change.

Furthermore, multicomponent school programmes are the most effective interventions for increasing PA and AT in school-children. The BTS programme is probably best described as a single component intervention. The US SR2S Programme incorporated the combination of education, enforcement, and a change of environment and showed a significant increase in ATS in the region of 5-20% (McDonald et al., 2013). The programme initially focused on curricular education and promotion of cycling and walking. Results showed an increase in cycling and walking of approximately 5% and 2%, respectively. The infrastructural component of this programme was found to be particularly important. The addition of crossings and sidewalks resulted in further increases in walking and cycling, of up to 20%. The BTS game did not explicitly target the factors that influence ATS, and there were no curricular, policy or infrastructural elements to the intervention. It is possible that there may have been some infrastructural barriers specific to Waterford City, which mitigated against a more significant increase in AT.

5.2.2.6 Distance, car dependency, and parental trip chaining

The lack of an intervention effect may also be attributed to the distance children lived from their school. In this study, children living further from their primary or secondary school were more likely to be driven school. This is consistent with both the international and Irish literature that shows that a longer distance from home to school is associated with lower rates of active commuting (Davison, Werder & Lawson, 2008; Martins et al., 2017; Williams et al., 2009; Nelson et al., 2008; Lambe, 2015). For instance, in Ireland, primary school-children living greater than 1.5 miles from their school were twice as likely to use passive modes of travel to school compared with children living within a 0.5-mile radius of their schools (Williams et al., 2009). In the same way, the threshold distances for walking and cycling to school in

Irish adolescents (15-17-year-olds) were found to be 1.5 and 2.5 miles, respectively (Nelson, Foley, Ogorman, Moyna & Woods, 2008). In the present study, it is worth noting that only 7.7% of the secondary school sample lived within 1.5km. This reduces both the likelihood of ATS and ultimately limited opportunity to play the game on journeys to and from school.

Analysis of the secondary school-children attitudes towards walking, cycling and driving, the sample showed an explicit car dependency. Regarding attitudes towards cycling/driving, the majority (61%) of children perceived car travels as something automatic. Further, 87% of the overall sample agreed that their parents are happy to drive them to school. In contrast, only 37.5% of children stated that they have parental support and encouragement to cycle to school. Results from attitudinal data towards walking/driving showed that 77% of children perceived driving to school by car as something automatic. Likewise, 82.4% of the sample stated that driving was the 'easiest way to get to school'. The majority (86%) of secondary school-children agreed that their 'parents/guardians are happy to drive them to school'. It is plausible that habit of driving, preference for car travel (especially in secondary school-children), and perception of car driving as something natural was a major obstacle during that intervention. Plausibly, measures devoted to a change of perceptions about active travel and car travel would bring more significant results.

Parents living in today's world face a variety of day-to-day demands. While being a working parent, using a car to drop children to school as part of a multiple destination trip is more convenient and time-efficient than walking or cycling for that matter (Dowling, 2000; Witten et al., 2013; Egli et al., 2018). In the presented study, 71% of children who travelled to school by car reported that their parents were travelling somewhere else after dropping them off as opposed to just returning home. It is probable that parental trip chaining lessened the overall effectiveness of BTS

5.2.2.7 The future of gamified interventions

As was outlined in the previous section, the most apparent advantage of gamification is its potential for generating a behaviour change in a variety of settings. Research suggests that gamified interventions may increase PA whilst simultaneously decreasing SB during leisure time (Furdu, 2017; Howe et al., 2016; Althoff, White & Horvitz, 2016; Sun, 2013, Garde et al.,2018; Hunter et al., 2015; Coombes & Jones, 2016; Harris, 2018, Nigg, Mateo & An, 2017). Mobile devices with inbuilt accelerometer sensors, GPS services, web applications, and social networking tools are highly accessible, and so provide an opportunity for low-cost PA interventions with a high level of penetration. Consequently, gamified interventions may be delivered anytime, anywhere, or ‘’just in time’’ for a behaviour change (Lenihan, 2012; Tong, 2015, p. 16). Indeed, the secondary school-children suggested that the technology associated with the game could be improved, e.g. with the creation of user-friendly smartphone app.

Furthermore, gamified interventions provide an alternative means of promoting PA. Its novelty increases interest with the game itself, and this ultimately works as a motivator for behaviour change (Barnett et al., 2013). Lumsden et al. (2016) suggest that aside from health-related benefits, gamified interventions may aid in the development of the strategic abilities of the players and enhance their working memory, visual attention, and processing speed. Moreover, there is good evidence that gamification stimulates cognitive development and promotes greater academic achievement as it activates the brain and promotes knowledge acquisition (Abu-Dawood, 2016; Turan, 2016). Furthermore, gamified interventions were found to promote community socialisation and the development of positive social relationships as well as the feeling of integration (Wong et al. 2017; Rao & Pandas, 2013). However, this again points to the need for a more community empowerment model of implementing games such as BTS.

The concept of gamification in health settings has gained some criticism over the years. Some claim that gamification is just a product created by marketers and general commercialism for easy profit (King, Greaves, Exeter & Darzi, 2013). Gamified interventions have been criticised for their unclear long-term

effects on PA and health. Research to date shows only short-term positive effects of gamified interventions that dissipate over time (Corepal et al. 2018; Howe et al. ,2016; Garde et al., 2018; Hunter et al., 2015). Another recognised disadvantage of gamified interventions in the health sector is the lack of a standardised, universally recognised model for effective gamification. There is an array of components used in these interventions, including the awarding of badges, points, or incentives; some promote competition while others adopt a team-based approach. Although the gaming industry has developed some guidelines, such as protecting personal data, the world of gamified health would benefit from an in-depth knowledge of what works and what does not in gamified interventions (Miller, Cafazzo & Seto, 2014; King, Greaves, Exeter & Darzi, 2013). A recent review of public health recommendations in health apps found that there is limited evidence of informed practice while creating health apps. In consequence, there is a lack of evidence-based PA apps on the market (Knight, 2015). Furthermore, it has been noted that it is difficult to measure the real impact of gamified interventions without conducting experiments related to the impact of the game/app design itself (Lister et al., 2014). Correspondingly, there is a need for more randomised controlled trials and double-blind experiments to eliminate the effect of individual game design elements on user experience, motivation level and health and wellbeing outcomes (Johnson et al., 2016). Lister et al. (2014) state that the current focus of gamified interventions is on motivational components of behaviour without adequately addressing capability or behavioural triggers, which, ultimately, decreases the potential of the intervention. Finally, Tong (2015) stated that gamification very often relies on competition as a catalyst for behaviour change. As much as it might be a catalyst for behaviour change, it might not work for everyone. Over time, competition-based approaches may be perceived as uninteresting and monotonous, thereby decreasing motivation to play (Corepal, 2018). It might even discourage a ‘player’ from taking part in the game. Therefore a combination of competition and cooperation may bring more significant results (Tong, 2015).

5.3 Study Strengths and Limitations

The main advantages of this study were the large sample size, the high response rates, and the use of seasonally matched surveys and the high external validity of the study. This was a natural experiment of a real-world physical activity intervention and added to the limited body of existing research in this area. One of the main limitations of the research was using self-report questionnaires without any objective measures of physical activity. This may have reduced the accuracy of the travel and physical activity data. The use of a repeat cross-sectional design may have reduced the likelihood of detecting an intervention effect. Collecting data from all school-children (and not just from those who played the game) made it difficult to measure the overall effectiveness of the intervention. The sample included respondents that had never participated in the game. Therefore, while there was no community-wide intervention effect for school-children, it is plausible to suggest that there may have been an intervention effect for those that frequently played the game. As Johnson et al. (2016) suggested in their review of gamification for health and wellbeing, there is a need for more well-designed studies employing randomised controlled designs and possibly studies comparing gamified and non-gamified interventions. Randomised controlled trials (RCT) provide the advantage of a controlled comparison of intervention groups with the best possible comparison group. Likewise, RCT's minimise the possibility of bias.

5.4 Recommendations

Recommendations for practice:

1. BTS should be more specific in terms of its target population and key messages. The game should;
    a) Target school-children and their parents, rather than all population groups within the community at once
    b) Focus on a single behaviour (active travel)
2. The intervention should target males and females at schools separately. Perhaps secondary school-children should not be the target of the game.
3. Future iterations of BTS should have greater intersectoral collaboration and community empowerment.
4. Schools and parents should be provided with training and information to promote the game
5. BTS should be a part of multicomponent AT or PA intervention. A multicomponent intervention should consist of cross-curricular education, promotional events at the school level, infrastructural improvements and policy development.
6. The persuasive architecture of the BTS game should be redeveloped, especially to:
    a) Incorporate smartphone technology (i.e. accessible via parents' phones) that would make it easier to access the leader boards, view locations and include more elements of the persuasive architecture of games.
    b) Redesign the 'flow' of the game to keep it interesting and engaging and to minimise the drop-off after the initial weeks
7. BTS boxes should be installed in a greater density especially in areas of good street connectivity, around schools and in recreational areas
8. The duration of BTS should be extended beyond six weeks and implemented across other times of the year.

Recommendations for research:

1. While Beat the Street provides opportunities for children to increase their physical activity by engaging in game-like active travel intervention motivation to remain in this study and play should be investigated. For instance the form of rewards that is more appealing and meaningful to children.
2. A comprehensive evaluation framework should be embedded in the intervention design of future BTS initiatives.
3. Inclusion of control groups should be widely reconsidered.

5.5 Conclusion

To summarise, there were no intervention effects detected for either PA or AT in school-children. Despite this, there were several positive findings. There was evidence that children that played the game frequently were more physically activity and the game encouraged children to visit new places and ones that were conducive to PA. There was also evidence for a trend towards an increase in the proportion of females walking home from school post-intervention. Primary school-children who played BTS regularly were three times more likely to ATS, whereas secondary school-children were eight times more likely to do so. The high awareness of the intervention was another major achievement of the game. The intervention was less popular among secondary school-children. The lack of an intervention effect was attributed to: the lack of community empowerment, the lack of persuasive architecture inherent in the game design, not having a defined target group and being a single-component intervention. Future gamified PA interventions that address these issues offer considerable potential to create a modal shift to active modes of travel in children.

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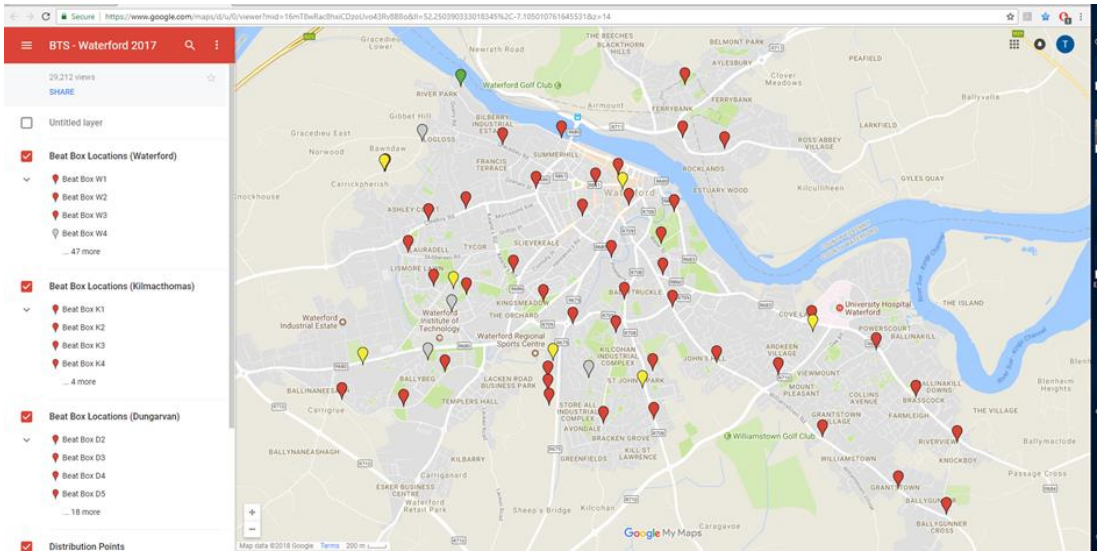
7 Appendices

Appendix A.

Online view of the map showing BTS boxes in Waterford County



Appendix B.

Beat the Street card distribution points in Waterford County

Ardkeen Library	Kingfisher Club	Waterford City Library	Carrickphierish Library
Lisduggan Library	Waterford Crystal Leisure Centre	Butler Community Centre	Dungarvan Library
Dungarvan Post Office Abbeyside	Phelan's Centra	Kilmacthomas Post Office	

Appendix C.

Beat The Street School Starter Pack

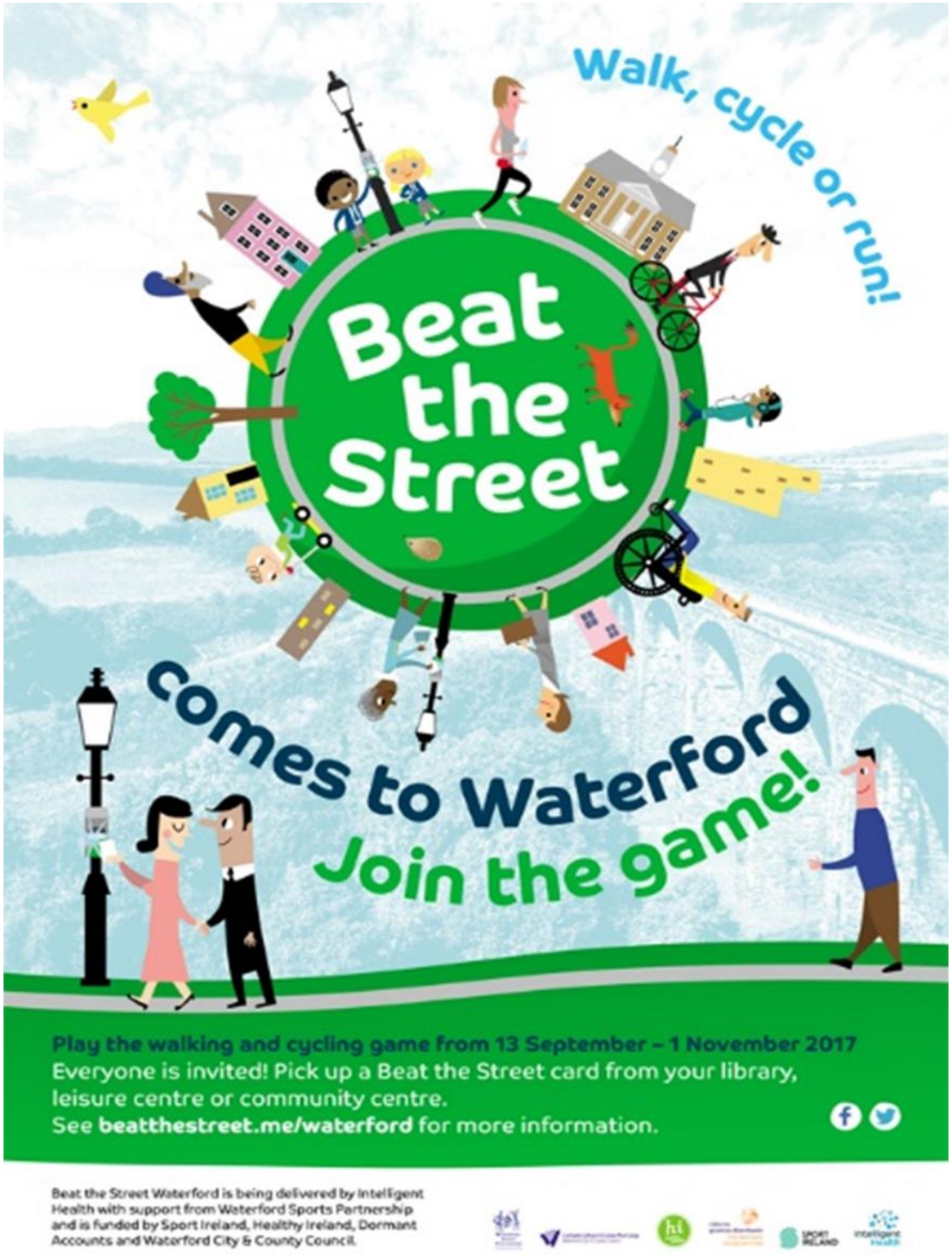


Figure C.1. BTS Waterford Poster

Figure C.2. BTS School banner

Figure C.3. BTS Posters/ flyers and an introductory parent pack

Appendix D.

The BTS Waterford website

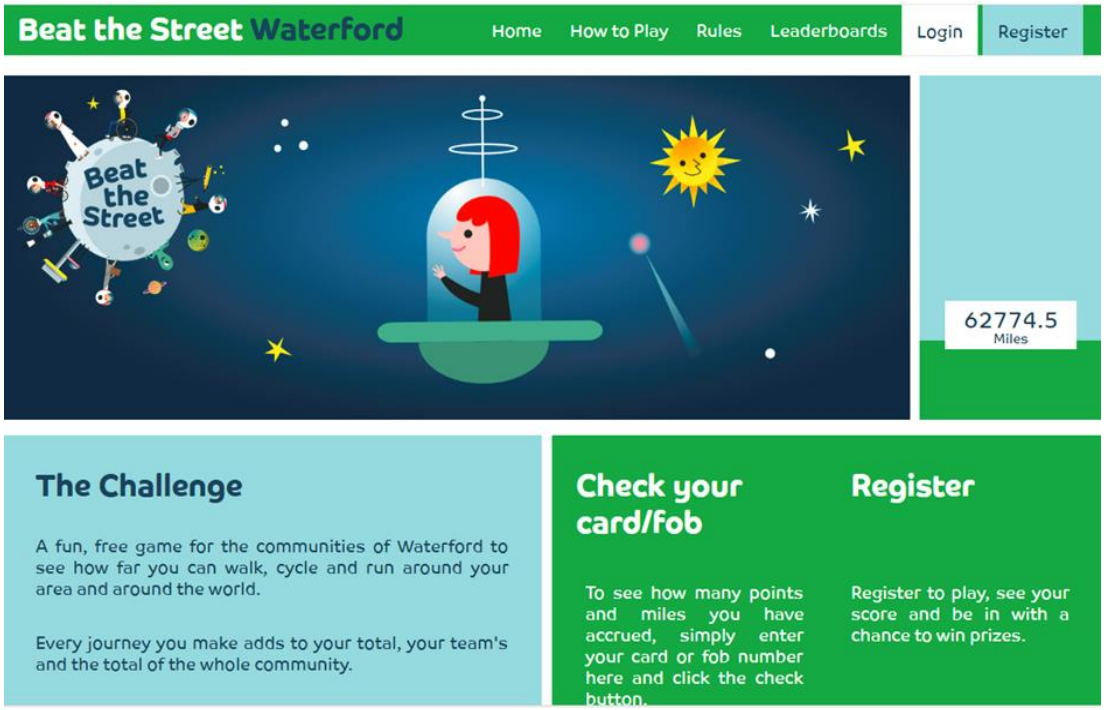


Figure D.1. BTS Waterford home page

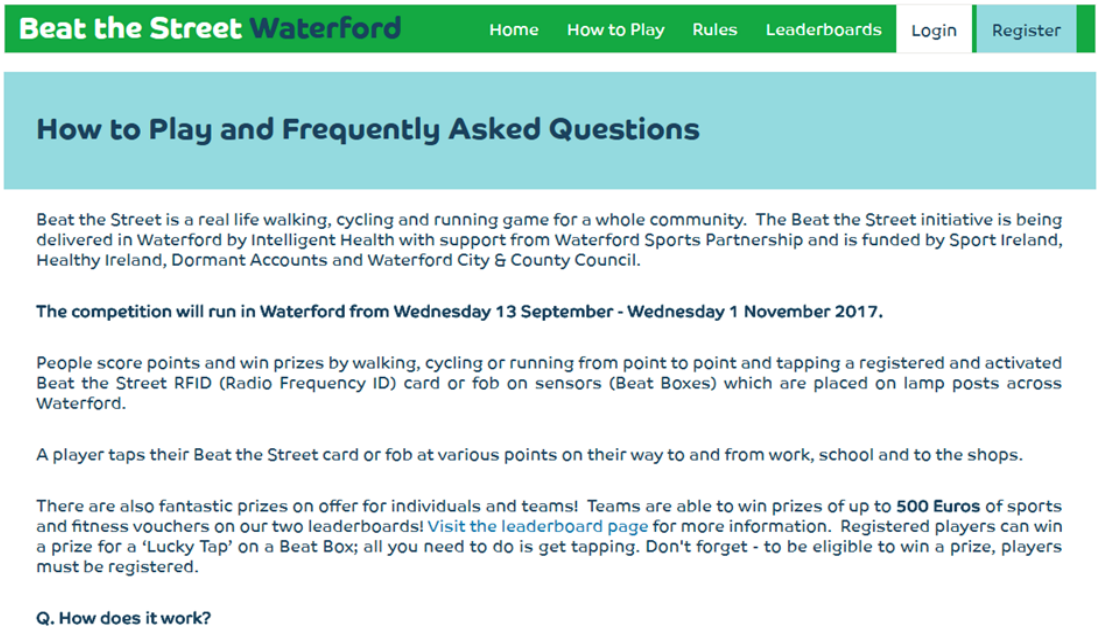


Figure D.2. BTS 'How to play' section

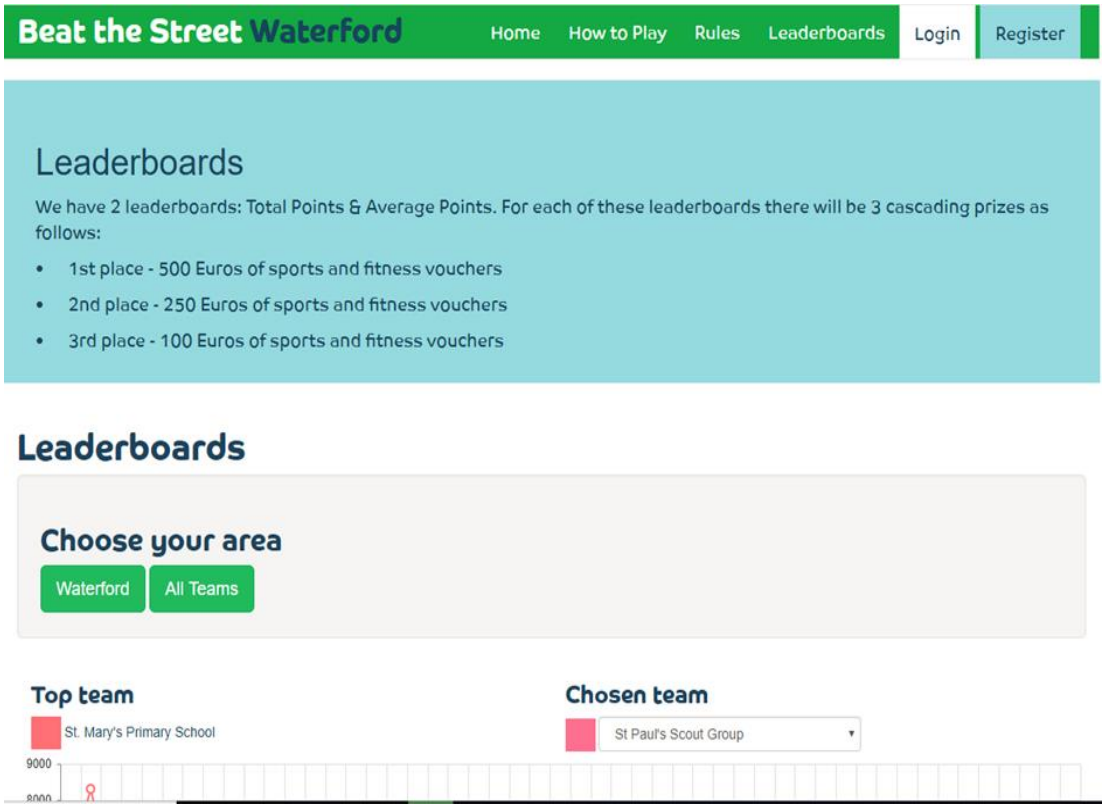


Figure D.3. BTS Waterford leader board (part 1)

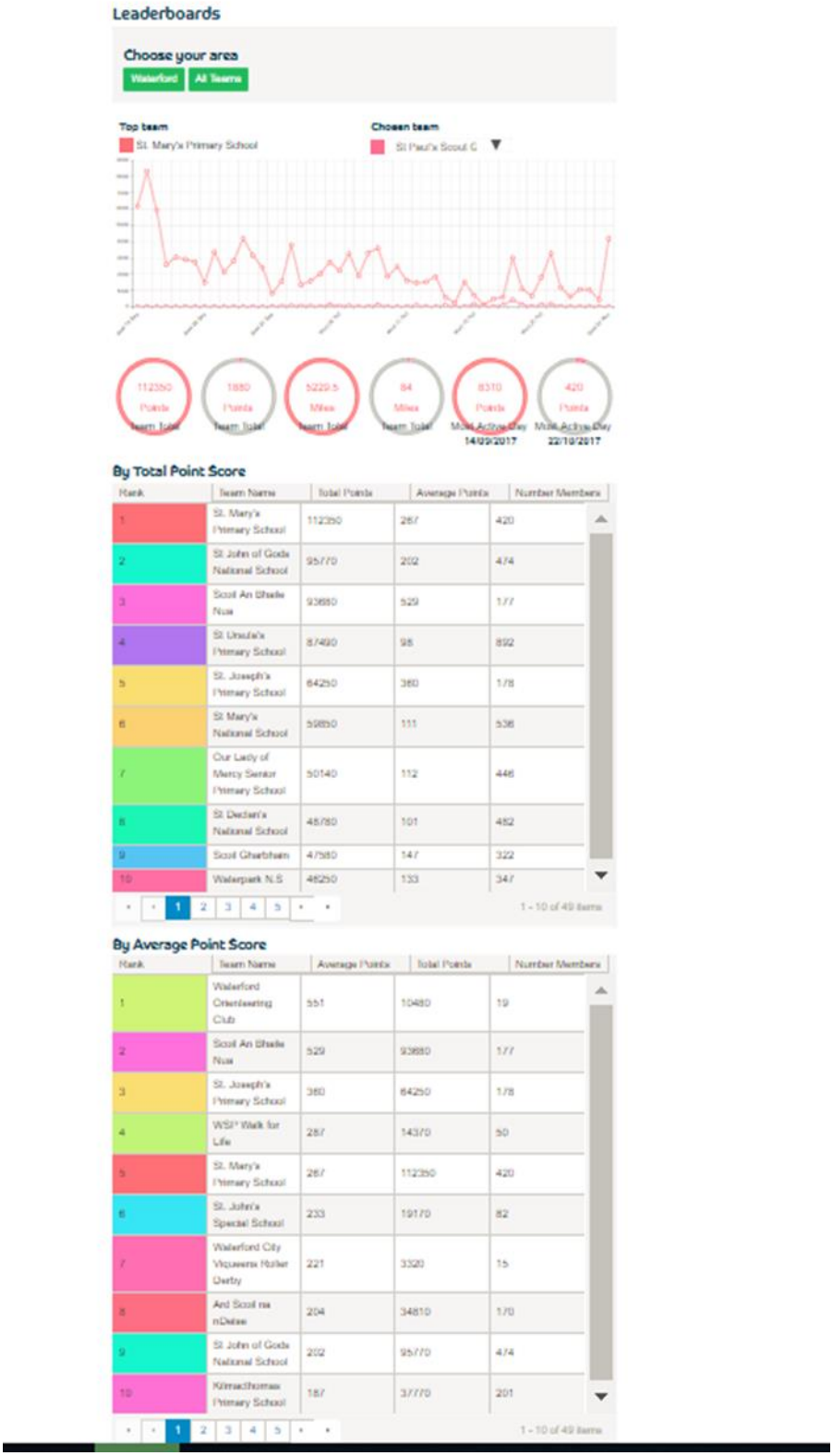


Figure D.3. BTS Waterford leader board (part 2)

Appendix E.

An example of social media contents shared on BTS Waterford Facebook and Twitter page

Figure E.1.The Beattie hedgehog. A free resource given to primary school-children who were tasked with going on 'adventures' over the weekend with their family and the mascot. Children were then asked to log their adventures into the diary provided

Figure E.2. BTS Waterford Community Prize

Figure E.3. BTS 'Walk a mile with a smile' photo competition

Figure E.4. BTS double points at certain boxes on given days

Figure E.5. BTS Promoting outdoor fitness event sponsored by Balance Fitness and supported by Waterford Viking Triangle

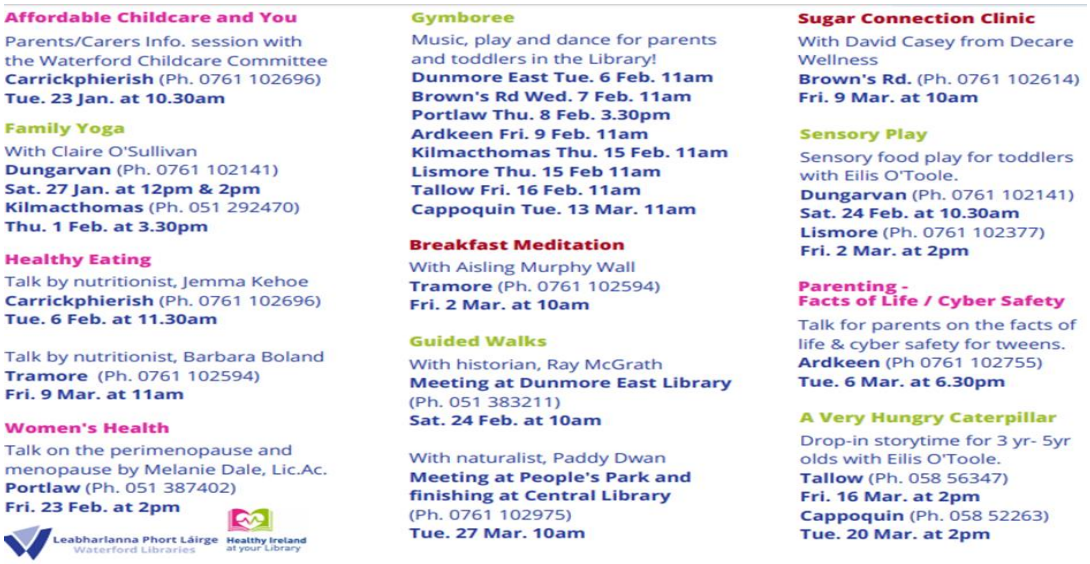


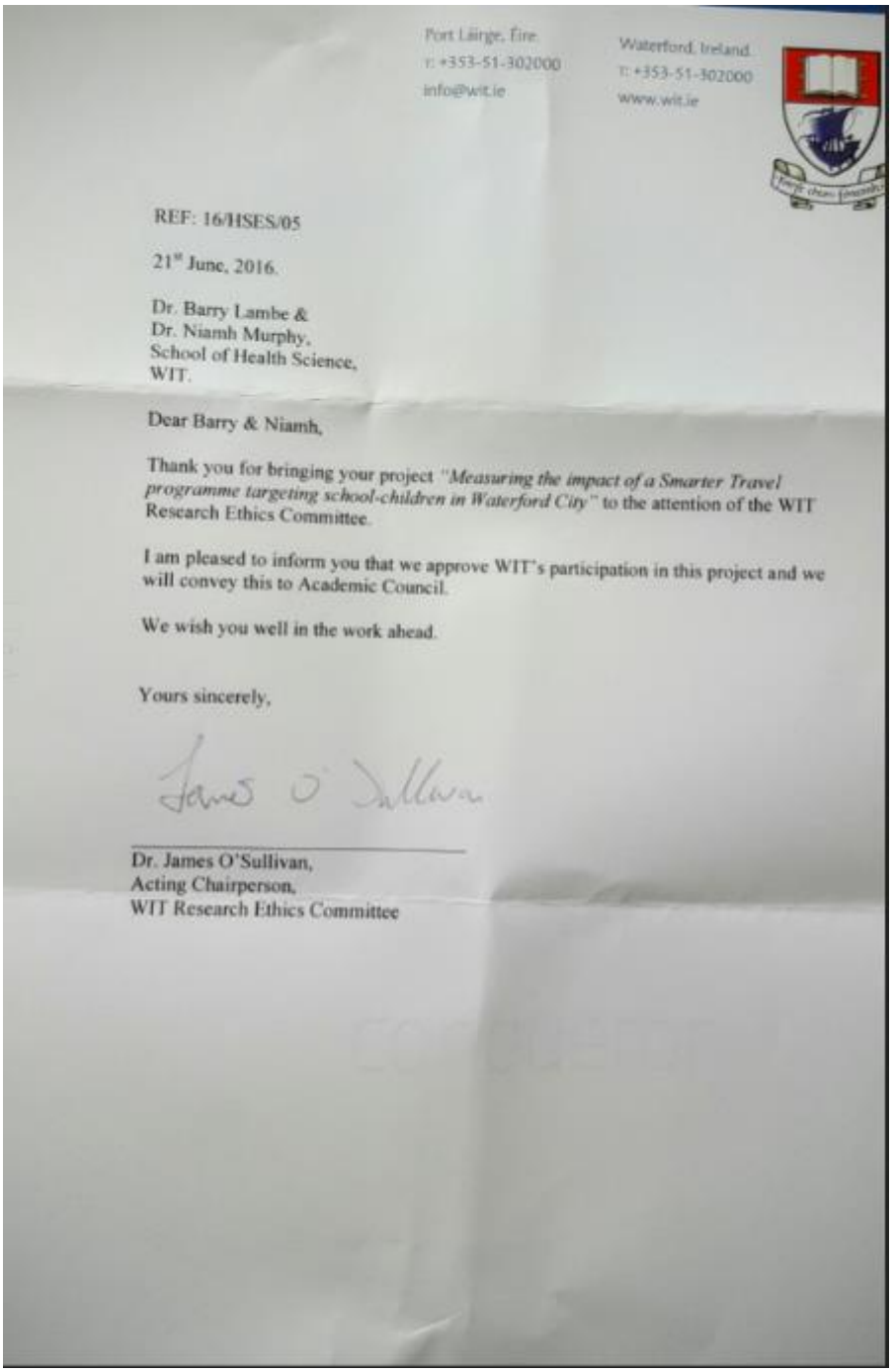
Figure E.6. BTS promoting local groups and meetings

Figure E. 7. An example of the BTS raising the profile of the local partner (part 1)

Figure E.8. An example of the BTS raising the profile of the local partner (part 2)

Appendix F.

Ethical Approval



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REF: 16/HSES/05

21st June, 2016.

Dr. Barry Lambe &
Dr. Niamh Murphy,
School of Health Science,
WIT.

Dear Barry & Niamh,

Thank you for bringing your project *"Measuring the impact of a Smarter Travel programme targeting school-children in Waterford City"* to the attention of the WIT Research Ethics Committee.

I am pleased to inform you that we approve WIT's participation in this project and we will convey this to Academic Council.

We wish you well in the work ahead.

Yours sincerely,

James O'Sullivan

Dr. James O'Sullivan,
Acting Chairperson,
WIT Research Ethics Committee

Appendix G.

Waterford City and County Council Information Letter to School Principals at Baseline

06 May 2016

Your Ref:
Our Ref: NK

XXXX XXXX
Our Lady of Mercy Secondary School
Ozanam St
Waterford

Dear Mary

I would like to bring to your attention, an important research study that is being conducted by Waterford City and County Council in conjunction with WIT.

The Council is working hard to promote walking and cycling for transport in the city and later this year, is implementing a comprehensive behavioural change programme to promote sustainable transport choices in the city.
The programme will target all primary and secondary schools.

In order to measure the effectiveness of this work over the next few years. It is essential that we conduct baseline surveys on attitudes and levels of physical activity and walking / cycling for transport and further follow up surveys to monitor any changes in the future.

The Centre for Health Behaviour Research in WIT, under the supervision of Dr Barry Lambe and Dr Niamh Murphy, are co-ordinating this aspect of the programme. To do this, we will be surveying a sample of our school-children from every primary and secondary school in the city in the autumn. We will mainly be asking them about how they currently travel to school and other destinations. We are also interested in knowing why they choose certain modes of travel. We would greatly appreciate your participation in this project. I have attempted to outline below some answers to further questions you may have.

What will the research involve in my school?
The research will only be done with 2nd and 5th year students **(replace with 5th and 6th classes for primary school letters)**. Information letters for parents will be provided to be sent home with students in September. The student questionnaires will be delivered to your school and students can fill them out during class. It will take approximately 10 minutes of class time to complete the questionnaire.

Why should we be involved?
The research and related programme will have several benefits for the people of Waterford City; improved health, reduced traffic congestion and reduced emissions. The information on physical activity and transport levels particular to your school will be made available to you. This will provide you with valuable information about how your students travel to school and how active they are over the next few years.

Thank you for taking the time to consider this research proposal. A member of the research team will be in touch with you in due course.

If you have any queries, please do not hesitate to contact me on XXXX XXXXXXX.

Yours sincerely,

_____
XXXX XXXX
Senior Executive Engineer
Waterford City and County Council

Appendix H.

Parent Information Letter at Baseline

Comhairle Cathrach & Contae Phort Láirge
Waterford City & County Council

Waterford Institute of Technology

Information about a student 'Smarter Travel' survey

Dear Parent / Guardian

Your child has been selected to complete a short survey in school on walking and cycling for transport. This short information letter is to help answer any questions you might have.

What is the study about?
Waterford City and County Council is working hard to promote walking and cycling for transport and reduce car travel in the city. WIT is helping them to measure the effectiveness of this work over the next few years. To do this, we will be surveying a large sample of our school-children in the city. We will mainly be asking them about how they currently travel to school and other destinations. We are also interested in knowing why they choose certain modes of travel.

What will happen if I allow my child to participate?
If you allow your child to participate they will be asked to complete a short questionnaire during class time. Only researchers involved with this study will have access to your child's information. However your child will not write down their name or address so they will be anonymous. All the same, all the results will be stored in a secure and locked location, either in a locked filing cabinet or on a laptop. It is important that you understand this information and that you are free to request that your child does not complete the questionnaire.

What do I need to do now?

a) If you are happy for your child to complete the questionnaire then you have nothing to do.
b) If you have further questions about the study e.g. you would like to see the questions, then don't hesitate to contact me (see contact details below).
c) If you would just rather your child DID NOT complete the questionnaire, then please contact me directly (see contact details below).

Thanks for taking the time to read this and please don't hesitate to contact me if you have any further questions.

Ms. Aneta Kuczynska
Dr. Barry Lambe

Tel: 087 614 0633
Email: aneta.kuczynska@postgrad.wit.ie

Centre for Health Behaviour Research
Department of Health, Sport and Exercise Science
Waterford IT

Appendix I.

Primary School Principal Letter at Follow-up

12th October 2017

Bríd O'Brien
Our Lady of Mercy Primary School
Military Road
Waterford

RE: Evaluation of the Beat the Street game in November

Dear Bríd,

In November 2016 your school participated in a short survey on physical activity and active transport in Waterford City. We (Department of Sport and Exercise Science in WIT) surveyed more than 3,000 schoolchildren in Waterford City. We are repeating this survey in November 2017.

Specifically we are using this data to evaluate the impact of the **'Beat the Street'** game on your students' physical activity levels. Beat the Street is a real-life walking and cycling game. Participants earn points by tapping special cards and fob keys onto sensors known as Beat Boxes which were located around Waterford City. The game came to an end on November 1st and now we want to know whether how effective the project was. The survey will be asking questions about your students' physical activity levels, their participation in active travel, and their participation in the game itself.

The Dept. of Sport and Exercise Science in WIT are coordinating the evaluation of the programme in both primary and secondary schools. To facilitate this, it is hoped that a short survey will be conducted in November 2017 with a sample of school-children from every primary and secondary school in the city. We would greatly appreciate your participation in this evaluation.

What will the research involve for my school?
The research will only be done with 5th and 6th class students in your school. Information letters for parents will be provided to be sent home with students in the 1st week of November. We will then call to your school at an agreed time and help your students complete the questionnaire during class time. Preferably this would happen during the week beginning Monday November 13th. It will take approximately 10 minutes of class time to complete the questionnaire.

We will be in touch with you shortly to confirm your participation in the research. Once you are happy to proceed we will arrange delivery of the parent information letters and schedule a time to complete the questionnaires in class.

Please do not hesitate to contact us if you have any further questions or would like to see a copy of the questionnaire.

Yours sincerely,

Ms. Aneta Kuczynska
Dr. Barry Lambe
Dr. Niamh Murphy
Dept. of Sport and Exercise Science, WIT

T: 087 614 0633
E: aneta.kuczynska@postgrad.wit.ie

Appendix J.

Secondary School Principal Letter at Follow-up

20th October 2017

Mary Meade
Our Lady of Mercy Secondary School
Ozanam St
Waterford

RE: Evaluation of the Beat the Street game in November

Dear Mary

In November 2016 your school participated in a short survey on physical activity and active transport in Waterford City. We (Department of Sport and Exercise Science in WIT) surveyed more than 3,000 schoolchildren in Waterford City. We are repeating this survey in November 2017.

Specifically we are using this data to evaluate the impact of the **'Beat the Street'** game on your students' physical activity levels. Beat the Street is a real-life walking and cycling game. Participants earn points by tapping special cards and fob keys onto sensors known as Beat Boxes which were located around Waterford City. The game came to an end on November 1st and now we want to know whether how effective the project was. The survey will be asking questions about your students' physical activity levels, their participation in active travel, and their participation in the game itself.

The Dept. of Sport and Exercise Science in WIT are coordinating the evaluation of the programme in both primary and secondary schools. To facilitate this, it is hoped that a short survey will be conducted in November 2017 with a sample of school-children from every primary and secondary school in the city. We would greatly appreciate your participation in this evaluation.

What will the research involve for my school?
The research will only be done with 1th class students in your school. Information letters for parents will be provided to be sent home with students in the 1st week of November (beginning of the week - November 6th). We will then call to your school to deliver the student questionnaires. The questionnaires will need to be completed during class time. Preferably this would happen during the week beginning Monday November 13th. It will take approximately 10 minutes of class time to complete the questionnaire. Once all the surveys have been completed, we will call again to collect them.

We will be in touch with you shortly to confirm your participation in the research. Once you are happy to proceed we will arrange delivery of the parent information letters and student questionnaires.

Please do not hesitate to contact us if you have any further questions or would like to see a copy of the questionnaire.

Yours sincerely,

_____

Ms. Aneta Kuczynska
Dr. Barry Lambe
Dr. Niamh Murphy
Dept. of Sport and Exercise Science, WIT

T: 087 614 0633
E: aneta.kuczynska@postgrad.wit.ie

Appendix K.

Parent Information Letter at Follow-up

Information about a student survey in your child's school

Dear Parent / Guardian

In November 2016, the Department of Sport and Exercise Science in WIT collected information about physical activity and active travel from more than 3,000 schoolchildren in Waterford City. We are repeating this survey in November 2017. This year your child has been selected to complete a short questionnaire during class. This short information letter will hopefully answer any questions you might have.

What is the study about?
We are evaluating the impact of the **'Beat the Street'** game on schoolchildren's physical activity levels. Beat the Street is a real-life walking and cycling game. Participants earn points by tapping special cards and fob keys onto sensors known as Beat Boxes which were located around Waterford City. The game came to an end on November 1st and now we want to know whether how effective the project was. The survey will be asking questions about your child's physical activity levels, their participation in active travel, and their participation in the game itself.

What will happen if I allow my child to participate?
If you allow your child to participate they will be asked to complete a short questionnaire during class time. Only researchers involved with this study will have access to your child's information. However, your child will not write down their name or address so they will be anonymous. All the same, the results will be stored in a secure and locked location; in a locked filing cabinet and in an encrypted electronic file. It is important that you understand this information and that you are free to request that your child does not complete the questionnaire.

What do I need to do now?

a) If you are happy for your child to complete the questionnaire then you have nothing to do.
b) If you have further questions about the study e.g. you would like to see the questions, then don't hesitate to contact us (contact details below).
c) If you would just rather your child DID NOT complete the questionnaire, then please contact us directly (contact details below).

Thanks for taking the time to read this and please don't hesitate to contact us if you have any further questions.

Ms. Aneta Kuczynska
Dr. Barry Lambe
Dr. Niamh Murphy
Dept. of Sport and Exercise Science, WIT

T: 087 614 0633
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Appendix L.

Primary School Survey at Baseline

Office use only *Code:*

Waterford Institute *of* Technology

Comhairle Cathrach & Contae Phort Láirge Waterford City & County Council

Smarter Travel in Waterford City

Primary School Survey

1. **Are you a:** Boy ❑ or Girl ❑

2. **What age are you?** _____

3. **What is the name of your school?**

   _____

4. **What class are you in?** 5th ❑ or 6th ❑

5. **How do you usually travel <u>to</u> school?** Tick one box to show the main method you use

   ❑  Walk (most or all of the way)

   ❑  Cycle

   ❑  Car

   ❑  Bus

   ❑ Other Please write it here_____

6. How long does your journey <u>to</u> school usually take?

- ❑ Less than 5 minutes
- ❑ 5 to 15 minutes
- ❑ 16 to 30 minutes
- ❑ 31 to 45 minutes
- ❑ 46 minutes or more

7. Who do you normally travel <u>to</u> school with?

- ❑ Travel on my own
- ❑ Parent
- ❑ Another adult
- ❑ Older child / teenager
- ❑ Child of same age or younger

8. How would you prefer to travel <u>to</u> school?

- ❑  Walk most or all of the way
- ❑  Cycle
- ❑  Car
- ❑  Bus
- ❑ Other Please write it here_____

9. How do you usually travel <u>home</u> from school? Tick one box to show the main method you use

- ❑  Walk (most or all of the way)
- ❑  Cycle
- ❑  Car
- ❑  Bus
- ❑ Other Please write it here_____

10. How many cars or vans are owned or available for use by those in your home? (tick one box only)

❑ 
1

❑ 
2

❑ 
3

❑4 or more 

❑ None

11. Are you allowed to walk to school on your own? Yes ❑ No ❑

12. Are you allowed to cycle to school on your own? Yes ❑ No ❑

13. Do you own a bicycle? Yes ❑ No ❑

14. Read this bit first!

Physical activity is any activity that increases your heart rate and makes you get out of breath some of the time. Physical activity can be done in sports, school activities, playing with friends or walking to school.

Some examples of physical activity are running, brisk walking, rollerblading, biking, dancing, skateboarding, swimming, soccer, basketball, football, rugby, hurling, camogie and surfing. For this next section add up all the time you spent in physical activity each day.

Over the past 7 days on how many days were you physically active for a total of at least 60 minutes per day? Tick one box only

0 days	1 day	2 days	3 days	4 days	5 days	6 days	7 days
❑	❑	❑	❑	❑	❑	❑	❑

15. Has your school done anything to promote walking or cycling to school?

Yes ❑

No ❑ → skip to question 15

I don't know ❑ → skip to question 15

16. Did it have a name?

_____

17. What did they do?

_____

_____

18. Have you noticed any changes in Waterford city to make it easier for people to walk or cycle?

Yes	❑	
No	❑	→ you are finished
I don't know	❑	→ you are finished

19. What changes have you noticed?

Thank you very much for your help 

Appendix M.

Primary School Survey at Follow-up

Office use only *Code:*

SPÓRT ÉIREANN SPORT IRELAND Waterford Institute *of* Technology WATERFORD SPORTS PARTNERSHIP

Primary School Survey

20. Are you a: Boy ❑ or Girl ❑

21. What age are you? _____

22. What is the name of your school?

_____

23. What class are you in? 5th ❑ or 6th ❑

24. How do you usually travel <u>to</u> school? Tick one box to show the main method you use

- ❑  Walk (most or all of the way)
- ❑  Cycle
- ❑  Car
- ❑  Bus
- ❑ Other Please write it here_____

25. How long does your journey <u>to</u> school usually take?

- ❑ Less than 5 minutes
- ❑ 5 to 15 minutes
- ❑ 16 to 30 minutes
- ❑ 32 to 45 minutes
- ❑ 46 minutes or more

26. Who do you normally travel <u>to</u> school with?

- ❑ Travel on my own
- ❑ Parent
- ❑ Another adult
- ❑ Older child / teenager
- ❑ Child of same age or younger

27. How would you prefer to travel <u>to</u> school?

- ❑  Walk most or all of the way
- ❑  Cycle
- ❑  Car
- ❑  Bus
- ❑ Other Please write it here_____

28. How do you usually travel <u>home</u> from school? Tick one box to show the main method you use

- ❑  Walk (most or all of the way)
- ❑  Cycle
- ❑  Car
- ❑  Bus
- ❑ Other Please write it here_____

29. How many cars or vans are owned or available for use by those in your home? (tick one box only)

❑  1

❑  2

❑  3

❑ 4 or more 

❑ None

30. Read this bit first!

Physical activity is any activity that increases your heart rate and makes you get out of breath some of the time. Physical activity can be done in sports, school activities, playing with friends or walking to school.

Some examples of physical activity are running, brisk walking, rollerblading, biking, dancing, skateboarding, swimming, soccer, basketball, football, rugby, hurling, camogie and surfing. <u>For this next section add up all the time you spent in physical activity each day.</u>

Over the <u>past 7 days</u> on how many days were you physically active for a total of at least <u>60 minutes</u> per day? Tick one box only

0 days	1 day	2 days	3 days	4 days	5 days	6 days	7 days
❑	❑	❑	❑	❑	❑	❑	❑

31. Have you heard of any special events or campaigns lately to encourage kids to do physical activity or walk or cycle to school?

Yes ❑
No ❑ → skip to question 14
I don't know ❑ → skip to question 14

32. Did it have a name?

_____

33. Are you allowed to walk to school on your own? Yes ❑ No ❑

34. Are you allowed to cycle to school on your own? Yes ❑ No ❑

35. Do you own a bicycle? Yes ❑ No ❑

36. Have you ever heard of the 'Beat the Street' game?

Yes ❑
No ❑ → thank you, you're finished
I don't know ❑ → thank you, you're finished

37. Do you get a keyring to play 'Beat the Street'?

Yes	❑	
No	❑	→ thank you, you're finished
I don't know	❑	→ thank you, you're finished

38. How often did you play 'Beat the Street'?

About every day	❑
Several times a week	❑
About once a week	❑
Less than once a week	❑
Never	❑ → skip to question 24

39. Who did you play 'Beat the Street' most often with?

Mostly on my own	❑
Mostly with my friends	❑
Mostly with my parents or another adult	❑

40. What was the thing you enjoyed the most about playing 'Beat the Street'? (Tick <u>One</u> Box Only)

Cycling my bike more	❑	Walking more	❑
Collecting points for my school	❑	Exploring new places	❑
Trying to win a prize	❑	The sound the boxes made	❑
Meeting other kids playing the game	❑	Tapping the boxes	❑
Spending more time with my friends	❑	Spending more time with my family	❑

41. Did you ever tap a Beat Box in a place you had never been before?

Yes ❑

No ❑ → skip to question 24

I don't know ❑ → skip to question 24

42. Where was the place you had never been before?

43. Compared with this time last year, are you…

Less physically active ❑

More physically active ❑

About the same ❑

44. Did the 'Beat the Street' game make you more physically active?

Yes ❑

No ❑ → skip to question 27

I don't know ❑ → skip to question 27

45. Will you continue this physical activity?

No ❑

Yes ❑

I don't know ❑

46. What do you think would make the 'Beat the Street' game better?

Thank you very much for your help 

Appendix N.

Secondary School Survey at Baseline

Office use only
Code:

Waterford Institute *of* Technology

Comhairle Cathrach & Contae Phort Láirge
Waterford City & County Council

Smarter Travel in Waterford City

Adolescent Survey

First some questions about you…

1. **What is the name of your school?** _____
2. **What year are you in?** 2nd ❑ 5th ❑
3. **Are you** Male ❑ Female❑
4. **What age are you?** _____ (years)
5. **How many cars or vans are owned or available for use by those in your home?** (tick one box only)

   None ❑ 1 ❑ 2 ❑ 3 ❑ 4 or more ❑

Now a question about how much physical activity you do

Read this bit first!

Physical activity is any activity that increases your heart rate and makes you get out of breath some of the time. Physical activity can be done in sports, school activities, playing with friends or walking to school.

Some examples of physical activity are running, brisk walking, rollerblading, biking, dancing, skateboarding, swimming, soccer, basketball, football, rugby, hurling, camogie and surfing. For this next section add up all the time you spent in physical activity each day.

6. **Over the past 7 days on how many days were you physically active for a total of at least 60 minutes per day?**

No days	1 day	2 days	3 days	4 days	5 days	6 days	7 days
❑	❑	❑	❑	❑	❑	❑	❑

Some questions about how you travel from place to place

These questions are about how you travelled from place to place during the last 7 days. It includes places like school, friends' houses, the shops, the cinema, and so on.

7. During the **last 7 days**, on how many days did you **travel in a motor vehicle** like a car, bus or train?

   _____ **days per week**

   ☐ No travelling in a motor vehicle → **Skip to question 9**

8. How much time did you usually spend on one of those days **travelling** in a car, bus or train?

   _____ **hours per day**

   _____ **minutes per day**

9. During the **last 7 days**, on how many days did you **cycle** for **at least 10 minutes** at a time to go **from place to place?**

   _____ **days per week**

   ☐ No cycling from place to place → **Skip to question 11**

10. How much time did you usually spend on one of those days **cycling from place to place**?

    _____ **hours per day**

    _____ **minutes per day**

11. During the **last 7 days**, on how many days did you **walk** for **at least 10 minutes** at a time to go **from place to place?**

_____ **days per week**

☐ No walking from place to place ⟶ **Skip to question 13**

12. How much time did you usually spend on one of those days **walking from place to place**?

_____ **hours per day**

_____ **minutes per day**

Some questions about how you travel to and from school

13. How do you usually travel **TO** school? i.e. the main part of your journey

Walk ❍ Cycle ❍ Car ❍ Bus❍

14. If you are driven to school in a car, where does the driver go after dropping you off;

❍ Straight home

❍ Somewhere else (e.g. to work, shopping or another school)

15. How do you usually travel **FROM** school? i.e. the main part of your journey

Walk ❍ Cycle ❍ Car ❍ Bus❍

16. How would you **prefer** to travel **TO** school?

Walk ❍ Cycle ❍ Car ❍ Bus❍

17. How long does your journey take from your home to the school gate?

_____ Minutes

18. Can you estimate the distance from your home to the school gate?

_____ Kilometres

If you only know the distance in miles you can give your answer here _____

19. Do you own or have access to a bicycle that is in working order? Yes ❍ No ❍

20. Are you allowed to ride your bicycle to go places on your own (like school, the park, friend's houses)

Yes ❍ No ❍ I don't have a bicycle ❍

Some more questions about travelling to school

21. How much do you agree with the following statements?

Travelling to school by <u>car</u> is something...

	Agree strongly	Agree	Neither	Disagree	Disagree strongly
I do frequently	❍	❍	❍	❍	❍
I do automatically	❍	❍	❍	❍	❍
I do without having to consciously remember	❍	❍	❍	❍	❍
That makes me feel weird if I do not do it	❍	❍	❍	❍	❍
I do without thinking	❍	❍	❍	❍	❍
That would require effort not to do	❍	❍	❍	❍	❍
That belongs to my daily routine	❍	❍	❍	❍	❍
I start doing before I realise I'm doing it	❍	❍	❍	❍	❍
I would find hard not to do	❍	❍	❍	❍	❍
I have no need to think about doing	❍	❍	❍	❍	❍
That's typically me	❍	❍	❍	❍	❍
I have been doing a long time	❍	❍	❍	❍	❍

22. How much do you agree with the following statements?

WALKING to school is something...

	Agree strongly	Agree	Neither	Disagree	Disagree strongly
I do frequently	❍	❍	❍	❍	❍
I do automatically	❍	❍	❍	❍	❍
I do without having to consciously remember	❍	❍	❍	❍	❍
That makes me feel weird if I do not do it	❍	❍	❍	❍	❍
I do without thinking	❍	❍	❍	❍	❍
That would require effort not to do it	❍	❍	❍	❍	❍
That belongs to my daily routine	❍	❍	❍	❍	❍
I start doing before I realise I'm doing it	❍	❍	❍	❍	❍
I would find hard not to do	❍	❍	❍	❍	❍
I have no need to think about doing	❍	❍	❍	❍	❍
That's typically me	❍	❍	❍	❍	❍
I have been doing a long time	❍	❍	❍	❍	❍

Questions about your thoughts on active travel to school

23. **To what extent do you agree with the following statements about CYCLING to school?**

	Agree strongly	Agree	Neither	Disagree	Disagree strongly
Cycling to school would be too tiring	❍	❍	❍	❍	❍
Cycling to school is not safe	❍	❍	❍	❍	❍
I am confident in my cycling ability	❍	❍	❍	❍	❍
I hate wearing a cycle helmet	❍	❍	❍	❍	❍
I don't like to cycle when the weather is bad	❍	❍	❍	❍	❍
I have lots of stuff to carry to school	❍	❍	❍	❍	❍
I couldn't be bothered cycling to school	❍	❍	❍	❍	❍
Cycling to school would take too long	❍	❍	❍	❍	❍
My friends would think I looked stupid if I cycled to school	❍	❍	❍	❍	❍
The clothes I wear make it hard to cycle	❍	❍	❍	❍	❍
Other students would think I looked stupid if I cycled to school	❍	❍	❍	❍	❍
My friends cycle to school	❍	❍	❍	❍	❍
My parents/guardians encourage me to cycle to places	❍	❍	❍	❍	❍
Cycling to school would ruin my hair	❍	❍	❍	❍	❍
My parents/guardians are happy to drive me to school	❍	❍	❍	❍	❍
I worry about my bicycle being stolen in school	❍	❍	❍	❍	❍
There is a safe cycling route from my house to school	❍	❍	❍	❍	❍
There is a direct cycling route from my house to school	❍	❍	❍	❍	❍
I live too far away from school to cycle	❍	❍	❍	❍	❍

24. **To what extent do you agree with the following statements about WALKING to school?**

	Agree strongly	Agree	Neither	Disagree	Disagree strongly
Walking to school would be too tiring	❍	❍	❍	❍	❍
I don't like to walk when the weather is bad	❍	❍	❍	❍	❍
I have lots of stuff to carry to school	❍	❍	❍	❍	❍
I couldn't be bothered walking to school	❍	❍	❍	❍	❍
Walking to school would take too long	❍	❍	❍	❍	❍
My friends would think I looked stupid if I walked to school	❍	❍	❍	❍	❍
Other students would think I looked stupid if I walked to school	❍	❍	❍	❍	❍
My friends walk to school	❍	❍	❍	❍	❍
Driving is the easiest way to get to school	❍	❍	❍	❍	❍
My parents/guardians encourage me to walk to places	❍	❍	❍	❍	❍
Walking to school would ruin my hair	❍	❍	❍	❍	❍
My parents/guardians are happy to drive me to school	❍	❍	❍	❍	❍
There is a safe walking route from my house to school	❍	❍	❍	❍	❍
There is a direct walking route from my house to school	❍	❍	❍	❍	❍
I live too far away from school to walk	❍	❍	❍	❍	❍

Questions about promoting walking and cycling in Waterford City

25. **Have you ever heard of a campaign to promote walking or cycling in Waterford City?**

    Yes ❑

    No ❑ → skip to question 28

    I don't know ❑ → skip to question 28

26. **What was it called?**

    _____
    ____

27. **What were the main messages or events surrounding this campaign?**

    _____

    _____

    _____

    _____

28. **Have you noticed any changes in the city to make it easier to walk or cycle for transport?**

    Yes ☐

    No ☐ → ***you're finished***

    I don't know ☐ → ***you're finished***

29. **What changes have you noticed?**

    _____

    _____

Thank you so much for your time!

Appendix O.

Secondary School Survey at Follow-up

Office use only
Code:

SPÓRT ÉIREANN
SPORT IRELAND

Waterford Institute *of* Technology

Waterford Sports Partnership

Adolescent Survey

First some questions about you…

23. What is the name of your school? _____

24. What year are you in? 1st ❑ 2nd ❑

25. Are you Male ❑ Female ❑

26. What age are you? _____ (years)

27. How many cars or vans are owned or available for use by those in your home? (tick one box only)

None ❑ 1 ❑ 2 ❑ 3 ❑ 4 or more ❑

Now a question about how much physical activity you do

Read this bit first!

Physical activity is any activity that increases your heart rate and makes you get out of breath some of the time. Physical activity can be done in sports, school activities, playing with friends or walking to school.

Some examples of physical activity are running, brisk walking, rollerblading, biking, dancing, skateboarding, swimming, soccer, basketball, football, rugby, hurling, camogie and surfing. <u>For this next section add up all the time you spent in physical activity each day.</u>

28. Over the past 7 days on how many days were you physically active for a total of at least 60 minutes per day?

No days	1 day	2 days	3 days	4 days	5 days	6 days	7 days
❑	❑	❑	❑	❑	❑	❑	❑

Some questions about how you travel from place to place

These questions are about how you travelled from place to place during the last 7 days. It includes places like school, friends' houses, the shops, the cinema, and so on.

29. During the **last 7 days**, on how many days did you **travel in a vehicle** like a car, bus or train?

_____ **days per week**

☐ No travelling in a vehicle → **Skip to question 9**

30. How much time did you usually spend on one of those days **travelling** in a car, bus or train?

_____ **hours per day**

_____ **minutes per day**

31. During the **last 7 days**, on how many days did you **cycle** for **at least 10 minutes** at a time to go **from place to place?**

_____ **days per week**

☐ No cycling from place to place → **Skip to question 11**

32. How much time did you usually spend on one of those days **cycling from place to place**?

_____ **hours per day**

_____ **minutes per day**

33. During the **last 7 days**, on how many days did you **walk** for **at least 10 minutes** at a time to go **from place to place?**

_____ **days per week**

☐ No walking from place to place ⟶ **Skip to question 13**

34. How much time did you usually spend on one of those days **walking from place to place**?

_____ **hours per day**

_____ **minutes per day**

Some questions about how you travel to and from school

35. How do you usually travel **TO** school? i.e. the main part of your journey

Walk ❑ Cycle ❑ Car ❑ Bus ❑

36. If you are driven to school in a car, where does the driver go after dropping you off;

❑ Straight home

❑ Somewhere else (e.g. to work, shopping or another school)

37. How do you usually travel **FROM** school? i.e. the main part of your journey

Walk ❑ Cycle ❑ Car ❑ Bus ❑

38. How would you **prefer** to travel **TO** school?

Walk ❑ Cycle ❑ Car ❑ Bus ❑

39. How long does your journey take from your home to the school gate?

_____ Minutes

40. How far is it from your home to the school gate in kilometres?

_____ Kilometres

If you only know the distance in miles you can give your answer here _____

41. Do you own or have access to a bicycle that is in working order? Yes ❑ No ❑

42. Are you allowed to ride your bicycle to go places on your own (like school, the park, friend's houses)

Yes ❑ No ❑ I don't have a bicycle ❑

Questions about your thoughts on active travel to school

30. **To what extent do you agree with the following statements about CYCLING to school?**

	Agree strongly	Agree	Neither	Disagree	Disagree strongly
Cycling to school would be too tiring	❍	❍	❍	❍	❍
Cycling to school is not safe	❍	❍	❍	❍	❍
I am confident in my cycling ability	❍	❍	❍	❍	❍
I hate wearing a cycle helmet	❍	❍	❍	❍	❍
I don't like to cycle when the weather is bad	❍	❍	❍	❍	❍
I have lots of stuff to carry to school	❍	❍	❍	❍	❍
I couldn't be bothered cycling to school	❍	❍	❍	❍	❍
Cycling to school would take too long	❍	❍	❍	❍	❍
My friends would think I looked stupid if I cycled to school	❍	❍	❍	❍	❍
The clothes I wear make it hard to cycle	❍	❍	❍	❍	❍
Other students would think I looked stupid if I cycled to school	❍	❍	❍	❍	❍
My friends cycle to school	❍	❍	❍	❍	❍

My parents/guardians encourage me to cycle to places	❍	❍	❍	❍	❍
Cycling to school would ruin my hair	❍	❍	❍	❍	❍
My parents/guardians are happy to drive me to school	❍	❍	❍	❍	❍
I worry about my bicycle being stolen in school	❍	❍	❍	❍	❍
There is a safe cycling route from my house to school	❍	❍	❍	❍	❍
There is a direct cycling route from my house to school	❍	❍	❍	❍	❍
I live too far away from school to cycle	❍	❍	❍	❍	❍
Cycling to school is something I do automatically without really thinking about it	❍	❍	❍	❍	❍
Driving to school is something I do automatically	❍	❍	❍	❍	❍

31. **To what extent do you agree with the following statements about WALKING to school?**

	Agree strongly	Agree	Neither	Disagree	Disagree strongly
Walking to school would be too tiring	❍	❍	❍	❍	❍
I don't like to walk when the weather is bad	❍	❍	❍	❍	❍
I have lots of stuff to carry to school	❍	❍	❍	❍	❍
I couldn't be bothered walking to school	❍	❍	❍	❍	❍
Walking to school would take too long	❍	❍	❍	❍	❍
My friends would think I looked stupid if I walked to school	❍	❍	❍	❍	❍
Other students would think I looked stupid if I walked to school	❍	❍	❍	❍	❍
My friends walk to school	❍	❍	❍	❍	❍
Driving is the easiest way to get to school	❍	❍	❍	❍	❍
My parents/guardians encourage me to walk to places	❍	❍	❍	❍	❍
Walking to school would ruin my hair	❍	❍	❍	❍	❍

My parents/guardians are happy to drive me to school	❍	❍	❍	❍	❍
There is a safe walking route from my house to school	❍	❍	❍	❍	❍
There is a direct walking route from my house to school	❍	❍	❍	❍	❍
I live too far away from school to walk	❍	❍	❍	❍	❍
Walking to school is something I do automatically without really thinking about it	❍	❍	❍	❍	❍
Driving to school is something I do automatically	❍	❍	❍	❍	❍

Questions about promoting walking and cycling in Waterford City

32. **Have you heard of any special events or campaigns lately to encourage kids to do physical activity or walk or cycle to school?**

Yes ❑
No ❑→ skip to question 26
I don't know ❑→ skip to question 26

33. **Did it have a name?** _____

34. **Have you ever heard of the 'Beat the Street' game?**

Yes ❑
No ❑→ thank you, you're finished the survey
I don't know ❑→ thank you, you're finished the survey

35. **Do you get a keyring to play 'Beat the Street'?**

Yes ❑
No ❑→ thank you, you're finished the survey
I don't know ❑→ thank you, you're finished the survey

36. **How often did you play 'Beat the Street'?**

About every day ❑
Several times a week ❑
About once a week ❑
Less than once a week ❑
Never ❑ → skip to question 36

37. **Who did you play 'Beat the Street' most often with?**

Mostly on my own	❑
Mostly with my friends	❑
Mostly with my parents or another adult	❑

38. **What was the thing you enjoyed the most about playing 'Beat the Street'?** (Tick <u>One</u> Box Only)

Cycling my bike more	❑	Walking more	❑
Collecting points for my school	❑	Exploring new places	❑
Trying to win a prize	❑	The sound the boxes made	❑
Meeting other kids playing the game	❑	Tapping the boxes	❑
Spending more time with my friends	❑	Spending more time with my family	❑

39. **Did you ever tap a Beat Box in a place you had never been before?**

Yes	❑
No	❑→ skip to question 33
I don't know	❑→ skip to question 33

40. **Where was the place you had never been before?**

41. **Compared with this time last year, are you…**

<u>Less</u> physically active	❑
<u>More</u> physically active	❑
About the same	❑

42. **Did the 'Beat the Street' game make you more physically active?**

Yes ❑

No ❑→ skip to question 36

I don't know ❑→ skip to question 36

43. **Will you continue this physical activity?**

Yes ❑

No ❑

I don't know ❑

44. **What do you think would make the 'Beat the Street' game better?**

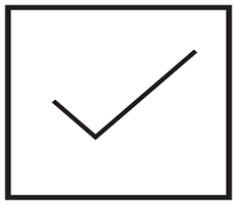
Thank you so much for your time!

Appendix P.

Standardised instructions for carrying out questionnaires in primary schools

On the day of the survey, please make sure to arrive on time with an adequate number of questionnaires for each school and spare writing tools.

- ✓ Use plain, simple language so children can understand the instructions
- ✓ In the classroom, please begin with a personal introduction (state your name and explain that you are surveying WIT).
- ✓ State the purpose of the questionnaire, e.g.: 'This questionnaire will show us how school-children travel to school (do they walk, cycle or do they travel by car) and how much physical activity they get.'
- ✓ State the content of the questionnaire (short and straightforward questions that require children to tick the box which represents their agreement with the statement). State that completion of the survey take will take only a few minutes



- ✓ Explain that the whole class is going to go through each question together so if anyone has a problem, all class can hear an answer it. Ask to raise a hand if they are questions.
- ✓ Explain that questionnaires are anonymous (meaning no names on top of the page) and they are usually one answer per question
- ✓ If the class is clear on how to fill out the surveys ask one or two volunteers to help with the survey distribution
- ✓ Give clear instructions on how to return the survey when complete (e.g. raised a hand so the research assistant can collect it)
- ✓ Please be patient and allow adequate time to complete each question
- ✓ At the end of the survey, accommodate extra time so children can check the answers.

Appendix Q.

Average and total points accumulated by members of primary and secondary schools in Waterford City; Number of children at schools

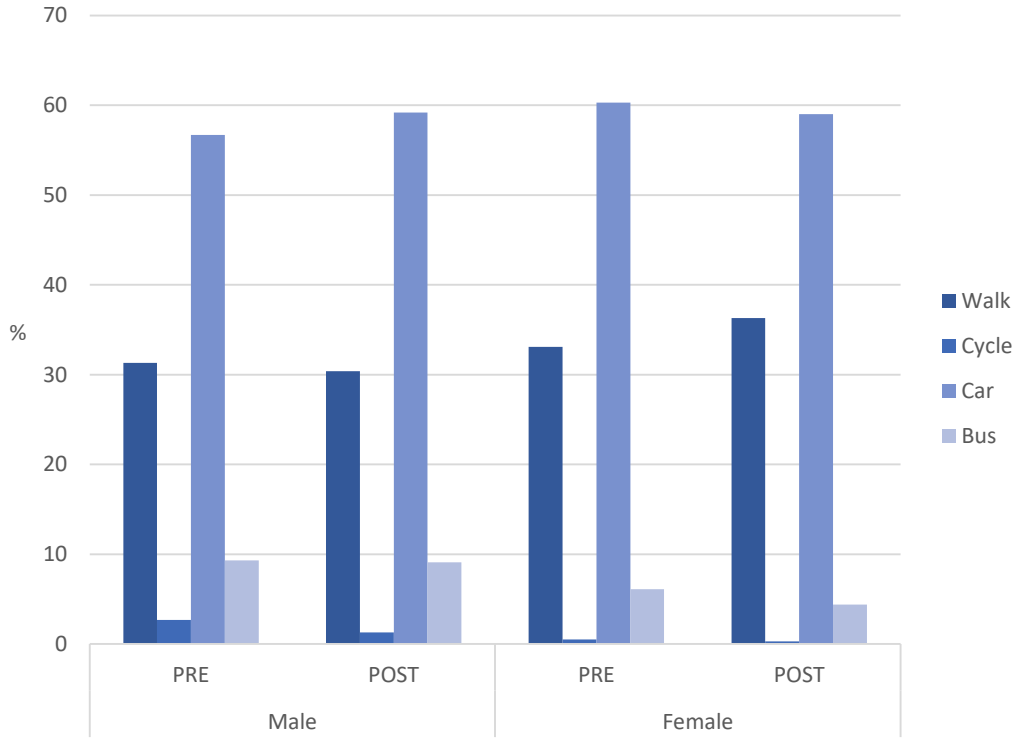
Note: Data on the number of children at school was based on information about enrolment for 2017/2018).

The underlined text presents secondary school.

School	Total Points	Average Points	Members	Number of children at school
1.	95770	202	474	260
2.	87490	98	892	687
3.	59850	111	536	275
4.	50140	112	446	304
5.	48780	101	482	No data
6.	46250	133	347	236
7.	30150	93	321	423
8.	23720	82	287	326
9.	21910	67	323	406
10.	21360	113	188	111
11.	20860	119	174	245
12.	18710	91	204	226
13.	16360	69	236	288
14.	**14370**	**99**	**144**	**496**
15.	10440	55	189	218
16.	9690	62	154	140
17.	8700	32	270	348
18.	**7630**	**56**	**134**	**475**
19.	6430	25	248	319
20.	**6260**	**44**	**142**	**852**
21.	**2660**	**49**	**52**	**398**
22.	**2270**	**25**	**89**	**915**
23.	**1830**	**32**	**57**	**1114**
24.	**1660**	**40**	**41**	**489**
25.	**830**	**No data**	**No data**	**286**
1.	**50**	**No data**	**No data**	**394**

Appendix R.

Travel from school at baseline and follow-up for males and females from primary intervention schools



Appendix S.

Actual and preferred mode of travel to school (and actual travel home from school) at follow-up

The car was the most common mode of travel to school as well as from school (68.4% and 57.6%; p<0.001). In contrast, the least common mode of travel to and from school was cycling (see figure S.1). A greater proportion of children walked home from school compared than to school (34.5% vs 26.4%; p<0.001). There was a discrepancy between the actual and preferred modes of travel to school. Cycling was the most preferred mode of travel to school (34.7%) but was also the least common mode of travel to school (0.9%; p< 0.001). Walking was the next most preferred mode of travel. More children indicated a preference to walk to school (32.5%) compared with the proportion that actually walked to school (26.4%; p<0.001). The proportion of children that would prefer to travel by car was 57% lower (p<0.001) than the proportion that actually travelled by car (29.4% vs 68.4%). Overall, twice as many school-children would prefer to use an active mode of travel to school compared with a passive mode of travel (67.3% vs 32.8%).

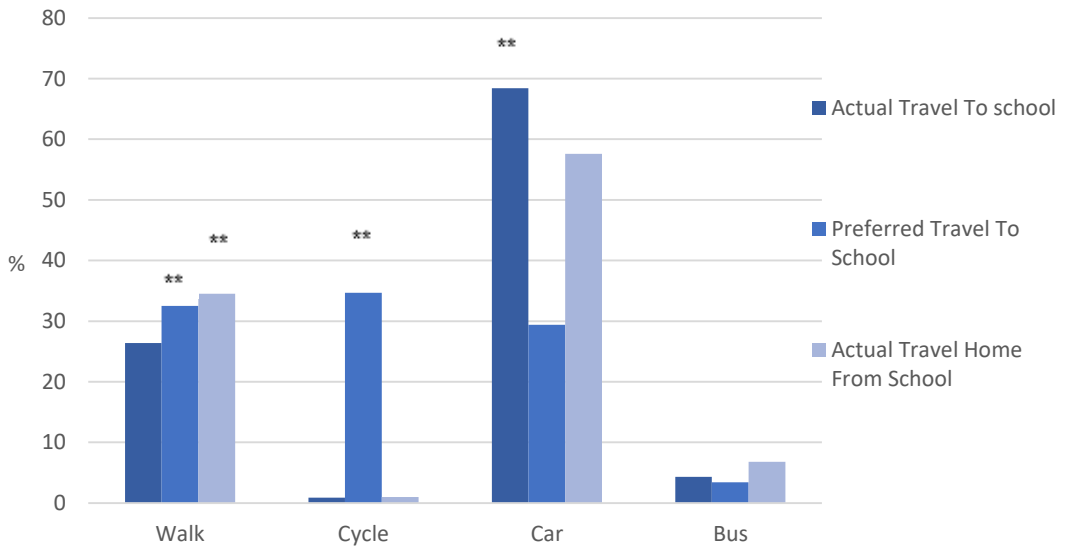


Figure S.1. Actual and preferred mode of travel to school (and actual travel home from school) in the total sample at follow-up
***p<0 .001*

Figure S.2 shows the comparison of the actual and preferred mode of travel to school separately for males and females. Overall, when compared with males, a greater proportion of females both travelled to school by car (70.2% vs 65.8%; NS) and indicated a preference to travel to school by car (31.1% vs 27%; p<0.01). Compared with males, a greater proportion of females stated that walking was their preferred mode of travel to school (35.3% vs 28.2%; NS). Conversely, a greater number of males reported that cycling was their preferred mode of travel to school (41.3% vs 30.3%; NS). For both males and females, AT was the most preferred way to travel to school (69.5% and 65.6%, respectively).

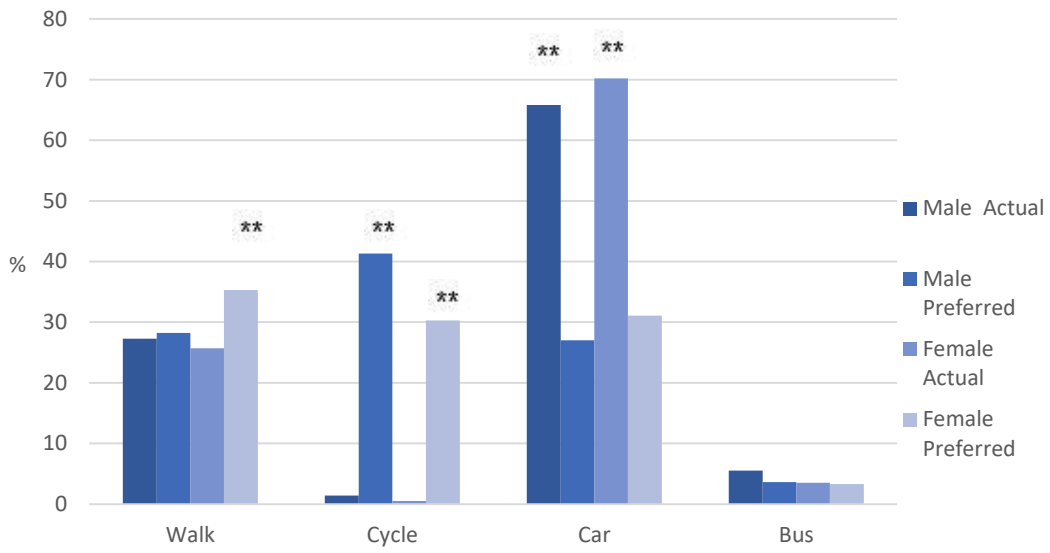


Figure S.2. Actual and preferred mode of travel to school at follow-up for males and females
***p<0 .001*