Promotion of Physical Activity in Children
Programme Guidance

A cost-effectiveness scenario analysis of four interventions to increase child and adolescent physical activity:

the case of walking buses, free swimming, dance classes and community sports

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May 1st, 2008

EXECUTIVE SUMMARY

We have taken a 'case-study' or scenario analysis approach to four very different physical activity programmes and considered the cost-effectiveness of each as far as was practical with the data. However, there is a large amount of uncertainty associated with these results as, due to the limitations of the evidence, it was necessary to make a number of unverified assumptions within the analyses, and the results were also shown to be sensitive to changes in these assumptions. Moreover, the generalisability of these results is also unclear as many of the cost estimates were based on specific programmes. This scenario analysis approach also highlighted some of the limitations of the data and the importance of the assumptions that are made in deriving cost-effectiveness estimates, in an area of public health where economic evaluation methods are underdeveloped. These include the paucity of data available to inform estimates of the relationship between physical activity and quality of life in children, the uncertainty as to whether the QALY (Quality Adjusted Life Year) captures the full benefits associated with many of these interventions, and the difficulty in estimating the long-term cost-effectiveness of these interventions.

With regard to the first intervention we estimated that the provision of walking buses would cost £121.71 per child. On average, we estimated that 50% of those who used the walking bus would have previously travelled by car and that for these children it would take an average of 22 minutes to walk to school. Assuming that every additional 30 minutes of physical activity is associated with a QALY gain of 0.00022243 then walking buses are estimated to have a cost per QALY of £4,007.63 per QALY. The cost per QALY under 'best case' and 'worst case' scenarios was estimated to be £2,431.51 and £26,306.42, respectively. For the dance class programme, using a similar methodology, the cost per child was estimated to be £57.82 and the QALY gain 0.0020972, giving a cost per QALY of £27,570.06. This estimate was however particularly variable, depending upon the assumptions made about the number of children in attendance, the cost of the project and associated increases in physical activity and QALYs gained. For free swimming based on a (per attendance) cost of £4.50, and a QALY gain of 0.00011122, the cost per QALY would be estimated to be £40,461.56. Finally, the cost per attendance of a community sports scheme was on average estimated to be £15.39 and when combined with a QALY gain of 0.00022243 gave a cost per QALY of £71,456.21. The community sports scheme particularly highlighted the difficulties of estimating the benefits of a programme in terms of QALYs which are specific to the child as such an approach would not encompass any non-health benefits or any benefits that might accrue to the family or wider local community that the scheme was designed to improve.

Summary estimates of the cost-effectiveness of the four interventions

	Cost per QALY (£)	'Best case' (£)	'Worst case' (£)
Walking Bus	4,007.63	2,431.51	26,306.42
Dance classes	27,570.06	15,545.23	150,794.48
Free swimming	40,461.56	-	-
Community sports	71,456.21	-	-

These results complement NICE's previous guidance on Physical Activity and the Built Environment (PDG PH008). Similar problems with economic modelling, due to a lack of direct evidence, were encountered and various *a priori* assumptions concerning cost and effect were made. Estimates of the cost per QALY derived in that study were also quite wide with the worst case scenarios much higher in cost value than with any of these four interventions reviewed here.

With these considerations in mind only walking buses was estimated to be cost-effective with respect to the assumed cost-effectiveness threshold of 20,000/QALY, due to their relatively low cost and that children benefited by being engaged in the activity on a regular basis over time. However, one can question whether this threshold is relevant to other sectors and it should be remembered that it was necessary to make a number of assumptions in order to produce these estimates. As such there is much associated uncertainty, as shown by the best and worse case estimates for dance classes. Thereby, caution should be taken from drawing too exact a conclusion about the relative cost-effectiveness of these interventions at this early stage of their evaluation.

INTRODUCTION

The National Institute for Health and Clinical Excellence ('NICE' or 'the Institute') has been asked by the Department of Health (DH) to develop guidance on a public health programme aimed at "promoting physical activity, play and sport for pre-school and school age children in family, pre-school, school and community settings". A number of previous reports have been produced in relation to this guidance [1-8]. Thus, readers are referred to these documents for information as to the need for this guidance, and the scope of the guidance [9]. A brief summary is as follows.

Current guidelines recommend that children should do a minimum of 60 minutes of at least moderate intensity physical activity each day [10]. However, i) up to a third of children aged ≤7 years are not active enough on a daily basis to meet the recommended levels of physical activity [11], and ii) girls are less likely than boys to achieve the recommended physical activity levels. Moreover, the number of children who walk to school has fallen significantly during the last decade [12].

As part of the guidance aimed at promoting physical activity, play and sport for pre-school and school age children in family, pre-school, school and community settings within this report we sought to investigate the possibility of estimating the cost-effectiveness of four specific interventions which were already provided in certain parts of the country: i) walking buses, ii) dance classes, iii) free swimming, and iv) a community sports scheme. Preliminary estimates of the potential cost-effectiveness of these interventions were made, based on the evidence that was available. However, it was necessary to make a number of assumptions in order to produce these estimates and we thereby also attempted to estimate the level of uncertainty surrounding them. These are discussed with some of the caveats in this paper as well as need for further research in areas where data or information is missing.

METHODS

This report uses standard economic methods of technology appraisal [13, 14] to estimate the incremental cost-effectiveness analysis of the four interventions. Thus, a further aspect of this report is to ascertain whether it is appropriate to use such conventional methods to evaluate these interventions which have a public health aspect.

No existing cost-effectiveness studies or other forms of full economic evaluation were found during the cost-effectiveness review [8]. However, within one of the effectiveness reviews [5] some significant evidence in the form necessary for economic evaluation was found especially for walking buses, but not for other interventions. Given the limited cost and benefit data available we also used 'threshold analysis' to estimate what level of cost or health gain (in terms of QALYs) per individual would be necessary in order to be cost-effective under NICE's assumed acceptability threshold (≤£20,000 per QALY). As we were not dealing with individual patient data in any of the studies we used an extreme form of two-way sensitivity analysis or 'best case' 'worst case' scenario analysis to test the robustness of the cost-effectiveness results. The worst case scenario is intended to indicate whether the intervention is still cost-effective when all relevant assumptions are at their least favourable. Therefore, as with all the assumptions made here, it is for local decision makers to interpret these findings in the light of local circumstances and hence decide whether the likely costs and benefits in their area will be similar.

WALKING BUSES

A walking bus has been defined as “a group of children who walk to school along a set route, collecting other children along the way at ‘bus stops’, escorted by several adult volunteers, one of whom is at the front (‘the driver’) and another is at the back (‘the conductor’)” [15] .

Methods

Estimating costs

We sought to estimate the total cost of setting up a walking bus, and apportion an element of this cost to each child. In the UK, the Department for Transport (DfT) has developed a document entitled ‘How to set up a walking bus’ [16]. Within this document the component parts of setting-up a walking bus are outlined, and we sought to assign a unit cost to each of these tasks. The review of the economic literature [8] did not reveal any cost-effectiveness studies of walking buses, and in the absence of any previous such studies it was necessary to make informed assumptions about the cost associated with each component task. Indeed one item that informed our assumptions was an estimate by the DfT that it would cost approximately £250 for an independent consultant to undertake a risk assessment of the walking route to school [16]. This Figure was reported in November 2006. Consequently, in line with another study that has estimated costs in the education sector [17], we used the GDP deflator figures [18] to inflate this cost to 2007/8 values. However, when estimating the costs associated with each component task it was apparent that a number of the component costs are dependent on the number of volunteers. We therefore also make an assumption about how many volunteers would be recruited within each walking bus.

One of the important component tasks that we needed to make an assumption about was the cost related to volunteer time. In the aforementioned study by Mackett [15] a qualitative survey was also undertaken with parents. That survey revealed that parental time shifts can be negative or positive, depending on circumstances - some parents ‘gain’ time as they are able to go to work earlier, but others ‘lose’ time as they act as volunteers and walking in the walking bus takes longer than walking would otherwise have taken. In the absence of any further data we assumed that these two opposite effects would, on average, produce a neutral effect on total parental time associated with transporting children to school i.e. that the cost of the extra volunteer time would be offset by the extra work/leisure time that would be created for parents who did not act as volunteers. We thereby assigned a zero cost to the volunteer time. But obviously this is a normative assumption and needs verification in future studies.

After making these various assumptions about the costs of each component task of setting up a walking bus these are summed in order to estimate the overall cost of providing a walking bus. Subsequently we also make an assumption about the average number of children who would use the walking bus, and then estimate the cost per child by dividing the total cost by the number of children. Finally, it should be noted that given the assumed lack of previous walking buses (ie. this is a *de novo* initiative for this particular group of children/parents/volunteers etc.) it can be referred to as the 'incremental' cost [19] as this is the estimated extra cost associated with providing a walking bus, compared to the situation that would have arisen if a walking bus had not been provided.

Estimating benefits

In order to estimate the benefits of children walking in walking buses it is necessary to make some further assumptions about what mode of transport children would have used if they had not walked in the walking bus - it would be inappropriate to assume that <u>everyone</u> in the walking bus would walk further as a proportion might have walked to school anyway. Thus we estimated the percentage of children who would previously have travelled to school by car (this is our estimate of the number of children who are undertaking additional physical activity). Similarly we also estimated the time it took for these children to walk to school, and the duration over which these benefits would be sustained. By combining these estimates it was possible to estimate the average per child increase in the level of physical activity that was associated with the provision of walking buses.

Estimating the QALY gain

Economists are keen to estimate benefits of interventions on a utility scale, where 0 equates to death and 1 equates to full health, as the use of such a common scale enables one to estimate the relative benefits of different interventions. In the absence of direct evidence as to the utility gain associated with using the walking bus we sought to estimate whether the procedure of 'mapping' could be used [20]. This involves using scores from non-preference based measures and transforming them into utility scores using pre-defined formulae. In particular we sought to estimate whether the aforementioned increase in the amount of physical activity (minutes) could be converted into an estimated utility gain. Subsequently, this would also enable one to calculate the number of Quality Adjusted Life Years (QALYs), where a utility score of 0.5 for 1 year would equate to 0.5 (0.5*1) QALYs.

We identified one study which had estimated the relationship between the amount of physical activity and the score on the utility scale. Within this study, by Beale et al. [21], it was estimated that every additional 30 minutes of physical activity, which was undertaken each month for the duration of 1 year, was associated with a gain in utility of 0.0026692 (standard error = 0.0001169). These results were obtained when estimating the relationship between scores on the EQ-5D and levels of physical activity, after controlling for certain demographic variables and measures of socio-economic status. The data which was used to estimate this relationship was collected in the Health Survey for England (HSE) conducted in 1999, 2003 and 2004 and included 19,790 individuals aged over 16 years.

The EQ-5D has five questions, where the respondent is asked to report the level of problems they have (no problems, some/moderate problems, and severe/extreme problems) with regard to mobility, self-care, usual activities, pain, and anxiety/depression [22]. Responses to these five dimensions are converted into one of

243 different EQ-5D health state descriptions, which range between no problems on all five dimensions (ie. 11111) and severe/extreme problems on all five dimensions (i.e. 33333). A utility score is assigned to each of these 243 health states, where the most common procedure for this is via the York A1 tariff [23], which is based on the preferences elicited from a survey of 3,395 UK residents. EQ-5D scores range between -0.594 and 1 (full health). Hence, although a good proxy for actual health gains of physical activity across the wider community, the EQ-5D gains attributed to walking buses and the other interventions assessed in this paper are indirect measures of actual outcomes.

There are however reasons why the above relationship between physical activity and utility on the EQ-5D may not equate to that which would be apparent for children who use walking buses. The first of these is the fact that the dimensions of the EQ-5D do not seem to be designed for children (e.g. the dimension of usual activities refers to work, study, housework, family or leisure activities) [22]. Second, the values which have been estimated on the EQ-5D were based on the preferences of 3,395 UK residents aged 18 and over [24]. Consequently, it is unclear whether these values are applicable to children as children themselves may have different preferences to adults for physical activity which would be expressed in the EQ-5D if it were directly applied to them. Also, physiologically children may differ in terms of health gains (and hence quality of life) from the same levels of physical exercise as taken in adults. Finally, it may not be the case that all forms of physical activity result in the same QALY gain (see above).

However, as the study by Beale et al. [21] is the only study which we know to have estimated the relationship between the QALY gain and the length of time in physical activity, we have used their estimates to derive the additional QALY gain from each extra 30 minutes of physical activity. This assumption is line with that made by others who have assumed that the QALY gain received by adults can be used to estimate the QALY gain received by children [25].

Beale et al. [21] estimated that 30 minutes of physical activity undertaken each month for the duration of 1 year would result in a QALY gain of 0.0026692 (standard error = 0.0001169). In total this QALY gain would thereby be achieved when undertaking an additional 6 hours of physical activity per year. If we make the assumption that the same QALY gain would also be realised in children, and that the gain is not specific to when the activity is undertaken (i.e. that 30 minutes of physical activity each month for one year provides the same QALY gain as 30 minutes of physical activity undertaken on twelve consecutive days, or any 6 one hour sessions of physical activity etc.) then it would be estimated that every 6 hours of physical activity is associated with a QALY gain of 0.0026692, and in turn that every 30 minutes of physical activity is associated with a QALY gain of 0.000222433333. We thereby used this value to directly transform levels of physical activity into QALYs, and estimate the QALY gain associated with the provision of a walking bus, compared to that which would have arisen if the walking bus had not been provided.

Cost-effectiveness

Levels of cost-effectiveness were calculated by estimating the incremental cost per QALY gain associated with each intervention, which is commonly referred to as the incremental cost effectiveness ratio (ICER) [19]. In order to undertake this calculation it is necessary to identify a comparator with which to compare the provision of a walking bus and in this instance the comparator is the situation that would have occurred if the walking bus had not been provided. Thus the ICER was calculated by dividing the estimated incremental cost associated with providing the walking buses by the QALY gain associated with the walking bus usage (cost per QALY). This value was then compared to the cost-effectiveness threshold (λ) value of £20,000/QALY. From previous publications [26-28] we inferred that heath care interventions which achieved a QALY gain for ≤£20,000 are generally deemed cost-effective.

We recognise however that this threshold is one derived and used widely within the health sector but may not be as acceptable, nor indeed perceived as relevant, in other public sector settings. For example, it is very unlikely that in education investments will be based solely on health gain as measured by QALYs. Obviously, human capital investment in the form of education is heavily dependent on having healthy children but it perhaps forms less benefit to education in developed countries where physical health is in the main quite good. That said,’ human capital’ arguments such as proof of long-term educational gain or class-room performance of increased physical activity - or a return on investment - might be a more persuasive argument to educators. Whilst some evidence as to the relationship between health improvement and educational attainment exists (especially in developing countries), it should not be taken for granted that cost-effective health interventions will be automatically financed from education or other public sector budgets (nor at least without some form of intersectoral compensation). See Drummond et al. [29] for further discussion.

Sensitivity analysis

Within cost-effectiveness analyses sensitivity analysis is often undertaken where one seeks to assess how robust conclusions are to changes in key assumptions. We thereby sought to change key assumptions and see what effect these had on estimates of cost-effectiveness. In particular, we sought to assess the impact of using ‘best’ and ‘worst case’ scenarios [19].

Threshold analysis

Threshold analysis seeks to identify the critical value of parameter that would need to be achieved in order for an intervention to be deemed cost-effective [19]. Thus, one could seek to estimate the critical cost value, below which it would be estimated that the intervention were cost-effective. Assuming an intervention is deemed cost-effective at a level of £20,000 then the critical cost value could be identified by holding the QALY gain constant and varying the assumed total cost until the cost-effectiveness estimate is equivalent to that of the cost-effectiveness threshold (λ). Similarly, the critical QALY gain at which an intervention would become cost-effective can be determined by holding the cost constant and varying the QALY gain until the cost per QALY value of £20,000 is reached. It is conventional to hold either cost or QALY constant in such an analysis, assuming that the other of these is known or estimated with a degree of confidence.

Results

Estimating costs

When the DfT figure of £250 for an independent consultant to undertake a risk assessment of the walking route to school [16] is inflated to 2007/8 levels this is equivalent to £258.13. We used this cost within our model, and informed by this estimate, also assumed that it would cost £258.13 to plan the route and a further £258.13 to train volunteers - we assumed that all volunteers would be trained in a group and that no fee would be paid for their time. With regard to insurance, the DfT point out that there is often no additional cost to provide cover for walking buses [16]. We therefore assumed that there would be no additional insurance costs, but that the opportunity cost of the administration necessary to confirm that that was the case would amount to £50. Further necessary component tasks of setting up a walking bus, which were outlined by the DfT [16], included the provision of a school meeting, distribution of newsletters and gaining the associated parental consent, and the timetabling of the route and we assumed the cost of these tasks would be £50, £75 and £75, respectively (see Table 1).

Table 1. Description of the component tasks of setting up a walking bus and the unit cost assumed applicable to task.

Component	Assumed unit cost (£)
Route planning	258.13
Risk assessment of the route	258.13
School meeting	100.00
Newsletter & parental consent	75.00
Insurance (administration cost)	50.00
Timetabling of route, volunteers and passengers	75.00
Training programme for volunteers	258.13
Criminal record check for volunteers	180.00
Tabards (for children and adults)	76.41
Volunteer time	0
Total	1330.78

As we have made assumptions about the cost of the above component tasks, in the absence of direct evidence, we were keen to verify that our assumptions were realistic. The DfT has made grants of £1000 available to schools who wish to set up a walking bus [30] and within this document (produced in November 2006) it was estimated that it would cost £800 per annum to pay a teaching assistant for 2 hours a week to organise and administer a walking bus and to seek children and parent volunteers for the walking bus. The cumulative cost of the first 7 tasks listed in Table 1, excluding the risk assessment of the route, amounts to £816.25 and we thereby consider our estimates to be in line with those outlined by the DfT.

A further additional cost was an enhanced Criminal Records Bureau (CRB) check for each volunteer, this currently costs £36 per person (www.crb.gov.uk). When undertaking a survey of walking buses in Hertfordshire Mackett [15] found that a total of 50 volunteers were associated with the 14 active walking buses who responded to the survey, this is equivalent to an average of 3.57 volunteers per bus. The survey that Mackett [15] undertook did however request information on the average number of volunteers on the day that it operates, and thus the reported figures would not thereby include those volunteers who were trained but no longer operate on the bus, or those volunteers which may operate the bus on alternate days. Within our model we thereby made the assumption that an average of 5 volunteers would be recruited when each bus was set up, and the associated CRB check cost would therefore be £180. An additional component task of setting up a walking bus is the provision of tabards [16], and it has been estimated that these would cost £3-5 per child and £5-7 per adult (2006/7 prices) [30]. In the same previously described survey of active walking buses [15] the mean number of children on each active bus was estimated to be 10.71 (see below for further details). We therefore assumed that, on average, 11 children's tabards and 5 adult's tabards would be required at £4.13 and £6.20, respectively. The estimated total cost of special clothing provision thereby equates to £76.41.

In total the above component costs amount to £1,330.78 (see Table 1). In the aforementioned survey by Mackett [15] in the 14 active walking buses surveyed there was an average of 10.71 children per bus (range 3-16). We thereby divided this cost by 10.71, giving an estimated incremental cost per child of £124.21.

Estimating benefits

In line with Mackett [15] we estimated that 50% of those who used the walking bus would have previously travelled by car, and that for these children it would take an average of 22 minutes to walk to school (at an average speed of 4.2 km/hour 22 minutes equates to a walk of 1,549 metres [15]).

In terms of how the long the walking bus will be used Mackett [15] found that of 26 walking buses on which detailed information was obtained, 14 were still active and 12 had ceased to operate. Given that the first walking bus in Hertfordshire was set up in 1998 this shows that walking buses often have a short life span. This concurs with survey data in New Zealand which showed that, for 56 walking buses surveyed, both current and discontinued walking buses had most commonly been operating 1.5 years [31]. Informed by the above, for the purposes of our model, we made the assumption that each walking bus would operate for 1 year. This may seem conservative, but it is perhaps balanced by the optimistic assumption that each child would use the walking bus to and from school five days per week. Mackett [15] found that this would not always be the case as some children would travel by car (e.g. when transporting musical instruments, in bad weather etc). Finally, we made the assumption that children attend school for an average of 38 weeks per year.

The cumulative effect of the above is that we estimated that, on average, each child who used the bus would walk for an extra 4,180 minutes over the 1 year period ie. the 50% of children who would have used a car would walk for 22 minutes each time they used the 'bus', and make 2 trips per day, 5 days per week, 38 weeks per year.

Estimating the QALY gain

Given that we assumed that every 30 minutes of physical activity is associated with a QALY gain of 0.000222433333, and walking buses would on average increase per child physical activity by 4,180 minutes over 1 year, then the estimated per child QALY gain associated with the provision of walking buses is estimated to be 0.03099238 QALYs.

Cost-effectiveness

The cost-effectiveness of providing a walking bus was estimated by using the incremental cost per QALY gain, and was found to be £4,007.63 per QALY (£124.21/0.03099238) (see Figure 1). Given that this falls below the £20,000-£30,000 per QALY threshold, which has been argued to denote the level of cost-effectiveness used by NICE [26-28], this suggests that the provision of walking buses represents a cost-effective use of resources.

Sensitivity Analysis

On the cost side one of the key determinants of the cost per child is the number of children who use the walking bus, and Mackett [15] has shown that this can vary quite widely between walking buses. Indeed in the sample of 14 active walking buses this was shown to vary between 3 and 16. Similarly, if the number of volunteers changes this will also have an impact on set-up costs of walking buses and in an in-depth study of 5 walking buses Mackett [15] found that the number of volunteers ranged between 4 and 15. In terms of benefits one of the key assumptions is the relationship between physical activity and QALYs. When estimating this relationship Beale et al. [21] found that a standard error of 0.0001169 was associated with the mean estimate of a 0.0026692 QALY gain for every 30 minutes of physical activity which is undertaken each month for 1 year, which equates to an estimated 95% confidence interval of 0.00244 to 0.002898 QALYs.

Informed by the above in the worst case scenario we assumed that 3 children used the bus, 15 volunteers were trained, and that every 6 hours of physical activity was associated with a QALY gain of 0.00244 (i.e. 0.00020334 QALYs for every additional 30 minutes of physical activity). In terms of costs this increased the cost of setting up the bus as more CRB checks were required and more adult tabards would be purchased. We also assumed that the cost of training volunteers would increase to £774.38 (i.e. that adults would be trained in 3 groups of 5 @£258.13 per time), however this was partially off-set by the need for fewer children's tabards. Under this scenario overall costs were estimated to be £2,235.94, which is equivalent to £745.31 for each of the 3 children. In terms of benefits the number of QALYs would be 0.02833199 which equates to a cost per QALY of £26,306.42 (see Figure 1).

In the best case scenario we assumed that 16 children used the bus, that 4 volunteers were trained, and that every 6 hours of physical activity was associated with a QALY gain of 0.002898 (i.e. 0.00024153 QALYs for every additional 30 minutes of physical activity). Under this scenario the overall cost would be estimated to be £1,309.24 which equates to a cost per child of £81.83. When this is combined with an increased QALY of 0.03365276 then this equates to a cost/QALY of £2,431.51 (see Figure 1). It can thereby be seen that the estimates as to the cost-effectiveness of walking buses are sensitive to changes in the number of children, the number of volunteers assisting with walking buses, and the assumed relationship between physical activity and QALY gain. However, even in the worst case scenario the cost/QALY is only slightly less favourable than the assumed threshold of £20,000/QALY.

Threshold analysis

If one assumes the incremental cost of a walking bus to be £124.21 then the provision of a walking bus would have a cost per QALY estimate below the threshold of £20,000/QALY so long as a QALY gain ≥0.00621 was achieved per annum. Similarly, if one assumes the QALY gain to be 0.03099238 then walking buses will have a cost per QALY estimate below the threshold of £20,000/QALY so long as the incremental cost is less than £619.85 per child. Given the aforementioned assumptions of our analysis both these scenarios seem feasible.

Caveats

The following effects, which we consider to fall outside the public sector perspective of this guidance, were not considered:

- Transport *'externalities'*; any potential effects on child pedestrian safety, or the level of road accidents.
- The potential cost savings of fewer car journeys. However, many cars will continue to be used as parents travel to work or elsewhere at the time of the school trip – Mackett et al. [32] found that only 28% of school trips were solely made to take a child to school.

Further potential *intangible* benefits not included in our model, see Mackett [15] for further discussion:

- Visual message as to the importance of walking e.g. changing the 'car culture'
- Reducing parking and congestion near the school may improve community relations
- Social aspects of the walking
- Teaching of road safety
- Discipline of timing in terms of leaving for school

DANCE CLASSES

Methods

The effectiveness reviews that were undertaken [4-7] did not report any evidence with regard to the effectiveness of dance classes. However, we sought to investigate the potential cost-effectiveness of this intervention, where in the absence of such evidence it would be necessary to make a number of assumptions in order to estimate both the costs and benefits of the intervention.

Estimating costs

Our estimates were based on the NRG Youth Dance & Health Project report [33] and the actual costs which we were informed to be associated with this project [34]. This project took place between October 2005 and March 2006, and dance classes were provided to 14 different groups of children (from 10 schools), where each group was scheduled to receive 10 classes (N.B. two groups did not complete the programme) [33]. The project took place within the school curriculum so individual participants were not charged but each school made a financial contribution [34]. After estimating the overall cost of the dance programme, in order to estimate the average cost per child it was necessary to make assumptions about the total number of children who attended these classes.

Estimating benefits

In line with the previous estimate as to the benefits of walking buses it was necessary to estimate the level of extra activity that is associated with the provision of dance classes. If the children who attend the classes do so at the expense of another physical activity (e.g. a swimming session that they would have otherwise attended) then the overall level of activity for that child is likely to be approximately equivalent to that which would otherwise have been the case. However, other costs such as those incurred by the family may change, but NICE guidance states that only a public sector perspective should be taken.

In addition to estimating the proportion of children whose level of physical activity changes as a result of the provision of dance classes, it was also necessary to assume how long each dance session was, and for how long the programme would be provided.

Estimating the QALY gain

In line with our previous analysis as to the benefits of walking buses we sought to convert this level of physical activity into QALYs, thus enabling the benefits of dance classes to be compared to other interventions on a common scale. In the absence of any data to inform this conversion, in line with our walking bus analysis, we assumed that 30 minutes of physical activity would result in a gain in a QALY gain of 0.00022243.

Cost-effectiveness

Again in line with previous cost-effectiveness analysis of walking buses, the cost-effectiveness of the provision of dance classes can be estimated by calculating the ICER (cost per QALY gain), where our comparator was the non-provision of dance classes.

Sensitivity analysis

In line with the aforementioned analysis of walking buses we sought to assess the impact that the use of best and worst case scenarios [19] would have on estimates of cost-effectiveness.

Threshold analysis

In line with the aforementioned threshold analysis for walking buses we sought to identify the critical cost value and QALY gain that would need to be achieved in order for the provision of dance classes to be deemed cost-effective. Again the threshold was assumed to be £20,000 per QALY.

Results

Estimating costs

Table 2 summarises the component costs that we were informed occurred in the NRG dance project, excluding the costs associated with research (£10,594.60) and production of a CD ROM (£3201.87) (NB. we have no further information as to how these costs were derived). The component costs sum to £15,203.53 (this is estimated to be equivalent to £16,127.76 at 2007/8 cost levels), where the largest cost is that associated with the artist (£5,806) - this is equivalent to a fee of 27.65 per hour if we assume the artists were paid to provide 14 groups with 10 sessions, each of which would take 1.5 hours of his or her time. It should also be noted that we could not infer from the report where the dance classes took place, and it is thereby unclear whether e.g. additional/lower costs for space hire and staff travel would be incurred if this project were to be set up elsewhere. Additionally, it should be noted that a qualified teacher was present in all classes in order to be able to assist with behaviour [33].

Table 2. Reported component costs of the NRG dance project (excluding research and educational CD production)

		Cost (£)
Project planning/preparatory work:		
Initial research into existing action research projects		500.00
Lead Artist fee - creative programme design/artist training		800.00
Artists' fees/travel - attending training/planning sessions		637.35
Coach hire – school group for pilot session		120.00
Space hire		254.70
Disclosures/refreshments		77.98
Documentation (Dissemination/advocacy)		269.70
Artists' fees		5,806.00
Artists' travel costs		1,515.44
Road-show event (end of project)		562.88
Additional schools workshop		151.80
Postage		64.03
Management Fee		4,000.00
Staff Travel		443.65
	Total	15,203.53

Informed by the above costs we assumed that it would cost £16,127.76 to run the aforementioned dance project elsewhere, and that the opportunity cost of the teacher who was also in attendance would be £25.00 per class (£3,300.00 in total - we assumed that each of the 14 groups received 9.43 classes, as explained below). According to the report [33] dance class sizes ranged from 21 to 28. If we therefore make the assumption that the average class size was 24 across each of the 14 groups the cost per child would be equivalent to £57.82 (19,427.76 / (24*14)).

Estimating benefits

In the absence of any evidence as to effect on the child's level of overall activity we assumed that for 50% of the children their overall activity would increase by the time associated with the dance class, and for the other 50% of children their overall level of activity would remain unchanged (though the dance classes were provided within the school curriculum it is unclear whether this came at the expense of other physical education sessions).

The guidelines for the NRG dance project do however state that each session should equate to at least one hour of delivery time, excluding time for changing [33]. We also had to estimate how many sessions each child would attend. Each of the 14 groups was scheduled to receive 10 sessions, though 2 of these were for research purposes and two groups did not complete the programme. We assumed that if this service were provided in another locality the 2 research classes could have been regular dance classes instead and that this would not change the costs reported in Table 2. Additionally, we also assumed that 6 dance classes were provided to the two groups which did not complete the programme. Therefore, across the 14 groups the average number of dance classes received would have been 9.43. If we also assume that each dance class lasts 1 hour then each child would on average receive 9.43 hours of dance classes. Taking account of our assumption that for 50% of children their overall level of physical activity would be unchanged this is equivalent to an average increase in physical activity of 4.71 hours (282.86 minutes) per child.

Estimating the QALY gain

Given that we assumed that every 30 minutes of physical activity is associated with a QALY gain of 0.000222433333, and dance classes on average increase per child physical activity by 282.86 minutes, then the estimated per child QALY gain associated with dance classes is estimated to be 0.0020972 QALYs.

Cost-effectiveness

The cost-effectiveness of dance classes was estimated to equate to £27,570.06 per QALY (£57.82/0.0020972) (see Figure 2). At over £20,000 per QALY this would suggest that it is uncertain whether dance classes represent a cost-effective use of scarce resources for producing health gain. However there is still some uncertainty surrounding the exact cost of these programmes and this may differ by place, locality and time of the activity (e.g. if opportunity costs are avoided). We have also been conservative perhaps regarding the number of children who previously were undertaking exercise, although we have assumed that those who participated in these classes undertook one hour of full physical activity per session attended, which may be too optimistic.

Sensitivity analysis

We judged that the key assumptions we had made were how many children would attend the dance classes (this would affect the cost per child), the actual increase in the level of physical activity that was associated with provision of dance classes, and the actual QALY gain associated with 30 minutes of physical activity.

In the best case scenario we assumed that the average class size was 28, that for 30% of children their overall level of physical activity remained unchanged, and that 30 minutes of physical activity was associated with a QALY gain of 0.00024153 (see the sensitivity analysis section of the waking bus analysis to see how this figure was derived), but left all other assumptions unchanged. This reduced the cost per child estimate to £49.56, and the cost per QALY to £15,545.23 (49.56/0.003188156) (see Figure 2).

In the worst case scenario we assumed that only 8 children would attend the dance class (it was stated that one teacher thought the young people needed to work in smaller groups [33]), that for 70% of children their overall level of physical activity remained unchanged, and that 30 minutes of physical activity was associated with a QALY gain of 0.00020334, but left all other assumptions unchanged. This increased the estimated cost per child to £173.46, and the cost per QALY to £150,794.48 (£173.46/0.001150322) (see Figure 2). Clearly, under these assumptions the intervention would not be cost-effective on health grounds alone.

It can thereby be seen that changes in the assumptions with regard to the number of children, the change in the level of physical activity and how that relates to QALY gains can result in large changes in the cost per QALY associated with the provision of dance classes. Thus, we consider that with the limited current evidence available there is large uncertainty as to whether the provision of dance classes is cost-effective or not. However, more detailed analysis of costs and benefits is required before any definitive conclusion can be reached.

Threshold analysis

If one assumes the incremental cost of the dance class programme to be £57.82 then the cost per QALY estimate would be below the threshold of £20,000/QALY so long as a QALY gain ≥0.002981 was achieved. Similarly, if one assumes the QALY gain to be 0.00104861429 then dance classes would have a cost per QALY estimate below the threshold of £20,000/QALY so long as the incremental cost is less than £41.94. The QALY gains were less than this critical QALY gain value in both the best and worst case scenarios and the costs were also higher than the critical cost value in both the best and worst case scenarios.

Caveats

- Due to lack of evidence in this area, we have not considered what the long-term effect on physical activity might be after the provision of the dance class programme.
- As we have taken a public sector perspective we have only considered the costs associated with the dance classes, and not considered those that might for example be incurred by both parents and children (e.g. purchase of shoes, clothes, travel, etc.).
- We have not considered the full educational or social capital benefit of dance but taken a strict health economic perspective. However, we recognise that the NRG Youth Dance & Health Project was set up to asses the objective health benefits of dance and so we must conclude tentatively that, with the assumptions we have made, there may be better ways of using resources to improve physical activity and health *per se*, other than in the way this intervention was designed and delivered.
- Different levels of attendance may occur if the programme were set up for different age groups, or for girls only, if this were the case then the costs and benefits of the programme may also change.

FREE SWIMMING

Evaluation as to the cost-effectiveness of free swim is difficult for the following reasons. Firstly, because there are a wide variety of free swim programmes that have been set up. These range from the open access free swim programmes which allow everyone of a particular age band to participate, compared to targeted schemes e.g. for some disadvantaged groups. Similarly, many schemes have also included further benefits, beyond free swimming e.g. in Glasgow a smart card was provided where further benefits included a discount at selected retailers and access to information and counselling services [35].

Secondly, though there is some reported cost data available, these tend to be just overall funding figures provided by government bodies, and it is unclear what that money has been spent on. Thirdly, within such programmes, it is extremely difficult to estimate (retrospectively) the numbers who benefit from the scheme and their respective levels of increased physical activity. The counterfactual position is difficult to assess. What woud be the number of new users i.e. how many would have previously attended public swimming anyway, compared to those whose attendance is effectively stimulated by the subsidy of the scheme?

Fourthly, it is unclear what the knock on effects of free swim might be e.g. timetable changes may reduce the level of swimming by other groups. The implications for staffing and others costs (e.g. cleaning chemicals) are also unclear, as are the long term effects (eg. regular swimmers might benefit more from access to a pool than adolescents incentivised to attend in the short-term). Finally, we are not aware of any data as to the typical length of a session for free swim participants (such participants may tend to have a different swimming ability to more regular users), and the benefit (increase in physical activity/QALY gain) that each session might provide. Presence of users within a pool area in an unstructured activity period is unlikely to produce such high levels of physical activity as derived by regular swimmers.

Methods

Estimating costs

We estimated the cost per additional attendance at a free swimming programme, informed by the costs and increased levels of attendance that had been estimated to have occurred in the aforementioned Glasgow programme.

Estimating benefits

In order to estimate the level of increase in physical activity associated the free swimming we estimated the proportion of children who undertook additional physical activity, and the additional level of physical activity that would be associated with each free swimming session.

Estimating the QALY gain

In line with our previous analysis as to the benefits of walking buses we sought to convert this level of physical activity into QALYs and assumed that 30 minutes of physical activity would result in a gain in a QALY gain of 0.00022243.

Cost-effectiveness

Again in line with previous cost-effectiveness analyses, the cost-effectiveness of free swimming was calculated by estimating the ICER (cost per QALY gain), where our comparator was the non-provision of free swimming.

Sensitivity analysis

In line with the analysis of walking buses and dance classes we considered the use of best and worst case scenarios [19]. However, we decided against this approach as we considered it difficult to come up reasonable estimates of the best and worst case scenarios. In previous analysis these could be, for example, informed by how the number of children/volunteers had varied across different walking buses. However, for this intervention we had no further information to estimate what the costs and benefits might be in 'best' and 'worst case' scenarios. That said, should 'best' and 'worst case' scenarios subsequently become available then it would be possible to judge whether they would result in this intervention being estimated as cost-effective by considering them in relation to the subsequent threshold analysis.

Threshold analysis

In line with the aforementioned threshold analyses we sought to identify the critical cost value, and QALY gain, that would need to be achieved in order for the provision of free swimming to be deemed cost-effective, where again the threshold was assumed to be £20,000 per QALY.

<u>Results</u>

Estimating costs

In Glasgow, where the scheme included a 'Young Scot Card' for children aged between 12 and 18 years, which had benefits beyond free swimming the total cost of the scheme was estimated to be £750,000 per annum [35]. From the report we were unable to ascertain the year to which this applied, but assumed it to be 2003/4. This thereby equates to £835,128.59 at 2007/8 levels. The scheme started in April 2001, and in 2003/4 the total number of attendances was estimated to be 400,000 compared to 240,000 in 2000/1. Assuming that attendance levels would have been 240,000 in 2003/4, had the free swimming scheme not been in place, this equates to £5.22 per additional attendance (835,128.59/160,000). In the light of the above cost, which included the cost of providing other services in addition to swimming, we made the assumption that the cost of providing free swimming would be approximately £4.50 per attendance.

Estimating benefits

We assumed that 50% of attendees would not have otherwise undertaken physical activity, and that each free swim session would encompass 30 minutes of physical activity. On average this equates to an average increase of 15 minutes of additional activity per free swim attendee.

Estimating the QALY gain

The 15 minutes of physical activity was estimated to be equivalent to a QALY gain of 0.0001112.

Cost-effectiveness

The cost per QALY gain associated with free swimming was estimated to be £40,461.56 (4.50/0.0001112).

Threshold analysis

If one assumes the incremental cost of the free swimming to be £4.50 per attendance then the cost per QALY estimate would be below the threshold of £20,000/QALY so long as a QALY gain ≥0.000225 was achieved. Similarly, if one assumes the QALY gain to be 0.0001112 then free swimming would have a cost per QALY estimate below the threshold of £20,000/QALY so long as the incremental cost is less than £2.22.

If the above assumptions are realistic then it would appear that free swimming is estimated to have a level of cost-effectiveness which is less favourable than the assumed level of the cost-effectiveness threshold.

Caveats

- The above cost estimates should be treated with considerable care, as they were informed by one programme which offered a number of benefits beyond free swimming and did not measure physical activity directly. Additionally, in 2003/4 Glasgow extended the free swimming programme to residents aged over 60 years [35], and thus we assume that the above reported attendance figures (and costs) are not based on providing the programme to children alone.
- Our analysis has been undertaken at the *per attendance* level, rather than at the level of the child. The potential importance of this assumption is discussed in the Discussion section.

Additionally, this analysis has raised other interesting economic issues. One of these is the extent and possible ways of measuring and valuing the '*opportunity costs*' - or forgone benefits in their next best use. This was particularly demonstrated by some targeted free swimming initiatives, (eg. children from disadvantaged and poorer socio-economic backgrounds etc.). Firstly, pool operators lost revenue from closing facilitates to the general public at various times of the week (although they were partially compensated for this as part of the LEAP study [36]). Secondly, those swimmers who would otherwise have used the pool on those occasions were prevented from doing so (and might perhaps have benefited *more* from the exercise taken than the children that participated in the programme).

COMMUNITY SPORTS SCHEME

This analysis was based on the a local community sports schemes, which involves a year-round programme of sports coaching and competition for young people aged seven to 16 years old. It takes place across the eight community council areas in schools, after school clubs, estates and community settings [37]. Evaluation of the community sports scheme was difficult for the same reasons that were above summarised for free swimming i.e. there were a variety of programmes, expenditure figures are only available at the overall programme level, and it is difficult to estimate the increase in physical activity per individual participant that results from the provision of a community sports scheme. Moreover, there is also the question as to whether the individual QALY approach captures the full benefits of the programme as there may be further non-health related benefits to the child and further benefits to both the family and the community that the scheme was designed to improve, such as greater community cohesion or reduced crime and disorder.

Methods

Estimating costs

We estimated the cost per additional attendance at a community sports scheme. This was calculated by dividing the *present value* of the costs of the local community sports scheme by an assumed number of attendances.

Estimating benefits

In order to estimate the level of increase in physical activity associated with the community sports scheme the proportion of children who undertook additional physical activity was estimated along with how much physical activity would be associated with each attendance at the community sports scheme.

Estimating the QALY gain

In line with our previous analysis we sought to convert this level of physical activity into QALYs and assumed that 30 minutes of physical activity would result in a QALY gain of 0.00022243.

Cost-effectiveness

Again in line with previous cost-effectiveness analyses, the cost-effectiveness of the community sports scheme was calculated by estimating the ICER (cost per QALY gain), where the comparator was the non-provision of a community sports scheme.

Sensitivity analysis

Again we considered the use of 'best' and 'worst case' scenarios [19]. However, we decided against this approach as we considered it difficult to come up reasonable estimates of the 'best case' and 'worst case' scenarios. In previous analysis these could be, for example, informed by how the number of children/volunteers had varied across different walking buses. However, for this intervention we had no further information to estimate what the costs and benefits might be in best and worst case scenarios. That said, should best and worst case scenarios subsequently become available then it would be possible to judge whether they would result in this intervention being estimated as cost-effective by considering them in relation to the subsequent threshold analysis.

Threshold analysis

In line with the aforementioned threshold analyses we sought to identify the critical cost value, and QALY gain, that would need to be achieved in order for the provision of free swimming to be deemed cost-effective, where again the threshold was assumed to be £20,000 per QALY.

Results

Estimating costs

The annual expenditure on the local community sports scheme was £508,000 in 2006/7 (see Table 3 for further details of the breakdown of this cost - we have no further information as to how these costs were derived) [38], this is equivalent to £524,510 at 2007/8 levels. The largest cost incurred was that associated with staff (£305,000 in total). A total of 6,000 coaching hours were provided by these staff [38], and the estimated cost per hour of coaching thereby equated to £50.83 at 2006/7 levels. In 2006/7 there were 33,000 attendances at the local community sports scheme by 8,010 young children [38]. This equates to a cost of £15.89 per attendance (524,510/33,000).

Table 3. Costs incurred in the provision of a community sports scheme (2006/7 prices)

	Cost (£)
Salaries - full time staff	£275,000
Salaries - sessional staff	£30,000
Training	£20,000
Vehicles	£48,000
Hire of facilities	£20,000
Marketing	£55,000
Equipment	£25,000
Hire of equipment for events	£25,000
Office equipment, phones, laptops	£15,000
Uniforms	£5,000
Admin support	£15,000
Total	£508,000

Estimating benefits

We are informed that each attendance will be associated with, on average, a one hour session of physical activity [38]. If we again assume that 50% of attendees would not previously have undertaken physical activity in that time, then it is estimated that on average attendance would increase physical activity by 30 minutes.

Estimating the QALY gain

Given our previous assumption about the relationship between physical activity and QALYs, an average increase of 30 minutes in physical activity would equate to a QALY gain of 0.00022243.

Cost-effectiveness

Hence the cost-effectiveness of the community sports scheme was estimated to be £71,456.21 per QALY (15.89/0.00022243).

Threshold analysis

If one assumes the incremental cost of the community sports scheme to be £15.89 per attendance then the cost per QALY estimate would be below the threshold of £20,000/QALY so long as a QALY gain ≥0.000795 was achieved. Similarly, if one assumes the average QALY gain to be 0.00022243 then the community sports scheme would be estimated to have a cost per QALY below the threshold of £20,000/QALY so long as the incremental cost was less than £4.45 per attendance.

This latter figure of £4.45 per attendance would mean that the community sports scheme would have a cost per QALY below the £20,000 threshold if it had a total cost less than £146,806, assuming it delivered the same number of attendances for that cost (and the QALY gain per attendance were the same). For example, if the overall cost of the scheme were £100,000 then the cost per attendance would be equivalent to £3.03, giving a cost per QALY of £13,623.42. This figure of £100,000 was used as an illustration as this is the level of contribution towards the community sports scheme that was made by the local health authority [38].

If the above assumptions are realistic then this suggests that with respect to only health benefits the community sports scheme has a level of cost-effectiveness which is less favourable than the assumed cost-effectiveness threshold. However, further analysis of costs and benefits would be required to confirm this conclusion.

Caveats

- Again the above analysis only encompasses that which was achieved as part of the organised community sports scheme. If the provision of the community sports scheme was to prove a catalyst for children to continue and undertake more physical activity, then this would provide additional benefits (and presumably costs). We have not been able to include such estimates in our model. We could find no evidence as to the long term benefits (and associated costs) of providing a community sports scheme (although this might be available through the local community sports scheme database if individual participants can be identified as participating over several years.).
- The above analysis also does not include the non-health benefits that the scheme was designed to improve, such as greater community cohesion or reduced crime and disorder.
- Our analysis has been undertaken at the per attendance level, rather than at the level of the child.

DISCUSSION

An important consideration in the assessment of benefit of all the programmes reviewed was the counterfactual question of how much exercise/physical activity were participants actually taking prior to the introduction of the programmes and how much physical activity would they have taken in other pursuits these had not have existed? In other words we needed to know the displacement of other physical activities to determine the net effect of the programme. However, this data did not exist in a form that was very helpful for economic evaluation in any of the four interventions and therefore had to be estimated. Part of the issue involves assumptions about whether students carry out exercise in their own time or only at school. If it is likely that a structured programme such as dance lessons replaces physical education lessons in the school curriculum then there may be only a small increment in extra physical activity per child. The same applies if out-of-school recreational football etc. is replaced with structured community sports.

Although a widespread problem in all health intervention trials it must be borne in mind that in the case of dance, swimming and community sports these were pilots under evaluation and hence may differ from actual results found in practice. Accordingly, we have not included any research costs associated with these demonstration projects in our estimates however we been unable to adjust the outcomes for any positive 'research effect' in terms of additional health gain.

With regards to measuring economic gain of attendees or individual participants, the extent to which the health impact of increasing physical activity differs between individuals cannot be accounted for in our economic modelling without more empirical evidence, which at present just does not exist. It is widely acknowledged that increasing physical activity in less active groups to some extent may be more beneficial than in those who are already quite active. However, the exact nature of the physical activity-wellness relationship both between individuals of different baseline levels of physical activity and changes within the same individuals is unknown. In this sense the linearity of our assumptions regarding the amount of time invested in taking physical exercise and the health benefits accruing in the same individual are still unconfirmed by the science of physical activity.

With regard to who gains extra QALYs from physical exercise we have taken the neutral (but perhaps naïve) view that an extra QALY gain is the same (ie.'a 'QALY is a QALY is a QALY'), no matter to whom it falls. But in reality these gains may be valued differently depending who receives the benefits. We also recognise that for equity considerations for public health, this may not be the only desirable goal for social investment purposes. Greater equity is often a key objective in promoting public health but in this analysis we did not take a *normative* view as to whether it is better to generate QALYs in one group of the population of children and adolescents or another. It may be argued however that it is 'worth' spending more to achieve a QALY in some deprived areas or among different age/gender or ethnic groups. However, knowing the opportunity cost in terms of how many QALYs are foregone in doing so is important if we are to understand these type of 'trade-offs' more clearly.

Health gain as measured by the QALY may be an inadequate measure of the wider social benefit derived from these programmes, as it would not, for example, encompass the benefits of community engagement and social cohesion. Such benefits could not be captured in our analysis as it we considered that it was not possible to incorporate these benefits into a common metric, although we acknowledge that in some cases these were equally important goals (e.g. community sports and dance). In this regard apportioning all the costs of a programme to gaining health and physical activity benefits may also be incorrect. A potential way forward may be to assume that other social benefits beyond the narrower health benefits will also be obtained in the process - so the QALY estimate is in fact a minimum benefit. Alternatively, one could only apportion that part of a programme's costs which is concerned with obtaining health benefits. But this also raises difficulties in ascertainment of which costs of programme can be directly apportioned to health? Currently economic evaluation techniques offer little guidance on such issues and further methodological research is required.

Only in the case of walking buses was there more substantive evidence of effectiveness found in the literature reviews undertaken previously (see Review 5: Children and active travel) though the review did not locate any studies which estimated the level of resource use associated with this intervention. Therefore assumptions had to be made to about typical costs of this intervention. For the other three interventions we were informed by locally available cost data, although in one case (free-swimming) this data was available as part of a national evaluation project [35]. For all interventions the cost estimates were combined with assumptions about the increased level of physical activity, and the relationship between physical activity and the number of QALYs (Quality Adjusted Life Years) gained, in order to produce estimates of the cost-effectiveness. In particular, within each of the analyses a constant relationship between the level of physical activity and QALYs gained (in the short-term) was assumed - although we also recognise that *intensity* of exercise along with duration may be important in terms of total energy expenditure, we were unable to adjust for different types of physical activity. Intensity/duration adjustments to physical activity measures would enable better economic evaluations to take place in the future.

Given the weakness of the data with regard to reporting changes in actual level of physical activity and a lack of baseline physical activity assessment in all of the interventions reviewed, it has not been possible to model the longer-term health consequences of any of the four programmes. Similarly, for certain interventions, it was impossible to distinguish accurately between number of attendances and individual participants; so that it is not known for how long and with how much intensity an individual participated in a given programme. Without a clear link to individual users and without any baseline epidemiological data (eg. co-morbidity) reported in any of the studies, we feel that it is inappropriate to extrapolate the relationship between short-term changes in health status and physical activity derived the *Health Survey for England (HSE) data* much beyond a year.

It would have been interesting to have known if children/adolescents introduced to these programmes went on to take increased levels of physical exercise over more sustained periods of time and hence reaped gains from avoiding chronic conditions such as obesity and related side-effects. But there is no long-term evidence to model these relationships at present. Alternative economic frameworks such as the 'human capital' approach might be worthwhile considering in the context of capturing wider public sector benefits but these 'returns' are difficult to measure without further extensive research. However estimating the 'return on investment' of early years' exercise programmes could then be viewed from various socially beneficial perspectives captured by the use of monetary valuation.

In all four programmes examined here we sought to estimate the additional minutes of physical exercise derived from the intervention itself. Minutes of exercise per year was the key variable necessary to derive the quality of life improvements. Other reported outcome measures such as categorical data of level of regular exercise would not have enabled a QALY to be estimated. We estimated the level of exercise that was new or, equivalently, the 'net gain' in physical activity. Once these extra minutes of physical activity were calculated they were multiplied a QALY gain which was inferred from the quality of life coefficient derived by Beale et al [21]. A major problem with this approach was the necessity of using EQ-5D values reported by adults (only) in the HSE. Adult utility gain from physical activity may be much different to that obtained by children. For a start children may be generally assumed to be in better health than adults of all ages and so any link between adult health improvement and physical activity may be distorted by pre-existing conditions but also a greater potential for improvement. On the other hand children or adolescents may not value or even enjoy physical exercise for its own sake and would possibly consistently rate health gains lower than their adult counterparts even though health gains from some activities may be more beneficial in this group.

No adjustment in the QALY calculation was made for mortality (neither upwards nor downwards) as it was assumed that individuals taking more exercise would neither have an increased longevity nor die prematurely, although these may be refinements required in any future models to be made relating to these issues.

Similarly, given there is too little known about the costs and benefits of these interventions to different groups of children we are unable to assess the potential cost-effectiveness of programme replication or expansion beyond what is known about the current programme level of operation. With only the current data to inform marginal decisions regarding expanding a programme to more children or making more sessions available to the same children, given the assumptions we made, this will only multiply costs and benefits in a constant cost ratio hence maintaining the same cost-effectiveness ratio. It is clear that more research is required in this area.

Finally, no account could be taken of assessing benefits to individuals other than those for whom the intervention was primarily intended. Some wider social benefits - known to economists as '*externalities*' - became apparent to us whilst working on this report. For example, we were informed that some parents of participants in the community sports and free swimming projects had reported a willingness to undertake more physical exercise themselves (although we do not know if they actually did or for how long). Similarly, it could also be argued that the parents who volunteered to lead the waking buses might take more physical exercise as a result of the programme. However, such benefits were not included in the analysis.

In the light of the above analysis we consider there to be three important issues that will impact upon the results obtained in future economic assessments of these interventions:

- What should be assumed about baseline fitness and exercise of participants - do all interventions increase total activity or do some result in the 'displacement' of other forms of physical exercise?
- What are the long term effects of the interventions? Will the effect of these interventions on physical exercise on health and quality of life last beyond programme, and act as a catalyst to undertake further physical activity?
- To what extent would estimates differ if equity considerations were incorporated into economic analyses? e.g. rather than basing the analyses on the number of attendances/sessions the benefits to particular participants could be estimated.

With regard to the final point, in calculating quality-adjusted life years, in the absence of other evidence, we have had to assume a relatively simple linear relationship between minutes of exercise taken and quality of life, as was estimated by Beale et al based on adults utility values [21]. Thus we made the assumption that each increased minute of physical exercise was of equal benefit to quality of life as we did not know the exact shape of the exercise-quality of life function, how long a period it might pertain for (for example, before decreasing returns to scale set in), nor whether it applies to all individuals, particularly to the focus of the PDG review namely children and adolescents. This linear relationship assumes that a 'QALY is a QALY is a QALY' etc. as 10 hours of physical activity undertaken by one individual would accrue the same total QALY gain as 10 people undertaking 1 hour of activity. In the same way, given the limited data available for some interventions, and the assumptions we made, both the cost per QALY gain associated with an individual child and per attendance were equivalent. However, we appreciate that in reality estimates of cost-effectiveness are likely to differ in both the short and long-term, and across different groups of children.

CONCLUSION

The cost-effectiveness literature within the areas reviewed is limited and the evaluations which have been undertaken often contained several missing components that would normally be included in a good economic evaluation. However we recognise that waiting for 'perfect information' about costs and benefits of these interventions is unrealistic (and likely to delay potentially valuable and cost-effective initiatives). Hence we have had to adopt a pragmatic approach and in so doing have made estimates of the costs of the programmes from financial and other data we were able to gain access to at the local level. In some case these were only general budgets and it was not possible to ascertain the costs associated with individual resource components. Also, in some cases the full extent of all opportunity costs remained undetermined. That said, we believe that we have identified the range of possible costs that should be considered in order to assess whether each of these interventions are likely to be cost-effective. However, it will be necessary for local policy makers to assess whether they are realistic and if some further adjustment is necessary e.g. to take account of the variation in the number of participants, attendees at the local level, or whether non-health benefits should also be considered.

Perhaps the biggest issue that remains to be resolved in the future is the method of calculating QALY gains from assessments of minutes of exercise taken. Whether these are accurately validated or imputed they should take account of *inter-alia* a) childrens' quality of life preferences directly b) increasing/decreasing returns of health gain to physical effort in individuals as opposed to number of attendees c) the input/output relationship of different forms of exercise taken and d) the possibility of wider community *externalities* involving health gains.

It should also be remembered that it was necessary to make a number of unverified assumptions in the above analyses. For example, we have discussed why adult QALY gains may not be applicable to children and why the QALY may not capture the full benefits of many of these interventions. Thus one might question whether it is appropriate to use standard economic evaluation methods when evaluating interventions which have a public health element. Similarly, due to the limitations of the available evidence our analysis did not seek to estimate the long term cost-effectiveness of these interventions.

With these considerations in mind only walking buses was estimated to be cost-effective with respect to the assumed cost-effectiveness threshold of 20,000/QALY, due to their relatively low cost and that children benefited by being engaged in the activity on a regular basis over time. However, one can question whether this threshold is relevant to other sectors and it should be remembered that it was necessary to make a number of assumptions in order to produce these estimates. As such there is much associated uncertainty, as shown by the best and worse case estimates for dance classes (see Table 4). Thereby, caution should be taken from drawing too exact a conclusion about the relative cost-effectiveness of these interventions at this early stage of their evaluation. To inform these decisions critical values for the threshold analysis are also presented in Table 5 (critical QALY values) and Table 6 (critical cost values)*.

Table 4. Summary estimates of the cost-effectiveness of the four interventions

	Cost per QALY (£)	'Best case' (£)	'Worst case' (£)
Walking Bus	4,007.63	2,431.51	26,306.42
Dance classes	27,570.06	15,545.23	150,794.48
Free swimming	40,461.56	-	-
Community sports	71,456.21	-	-

*see individual threshold analysis sections for estimates of the critical cost or QALY gain that would be necessary in order for these interventions to be deemed cost-effective.

Table 5. Threshold analysis - the critical QALY gain required in order for the intervention to have a cost per QALY below the threshold of £20,000/QALY

	Base-case cost estimate (£)	Critical QALY value	Estimated
Walking Bus	124.21	≥0.006210	0.03099238
Dance classes	57.82	≥0.002981	0.00209723
Free swimming	4.50	≥0.000225	0.00011122
Community sports	15.89	≥0.000795	0.00022243

Table 6. Threshold analysis - the critical cost value required in order for the intervention to have a cost/QALY below the threshold of £20,000/QALY

	Base-case QALY gain	Critical cost value (£)	Estimated (£)
Walking Bus	0.03099238	≤619.85	124.21
Dance classes	0.00209723	≤41.94	57.82
Free swimming	0.00011122	≤2.22	4.50
Community sports	0.00022243	≤4.45	15.89

Figure 1. Estimates as to the cost-effectiveness of a walking bus.

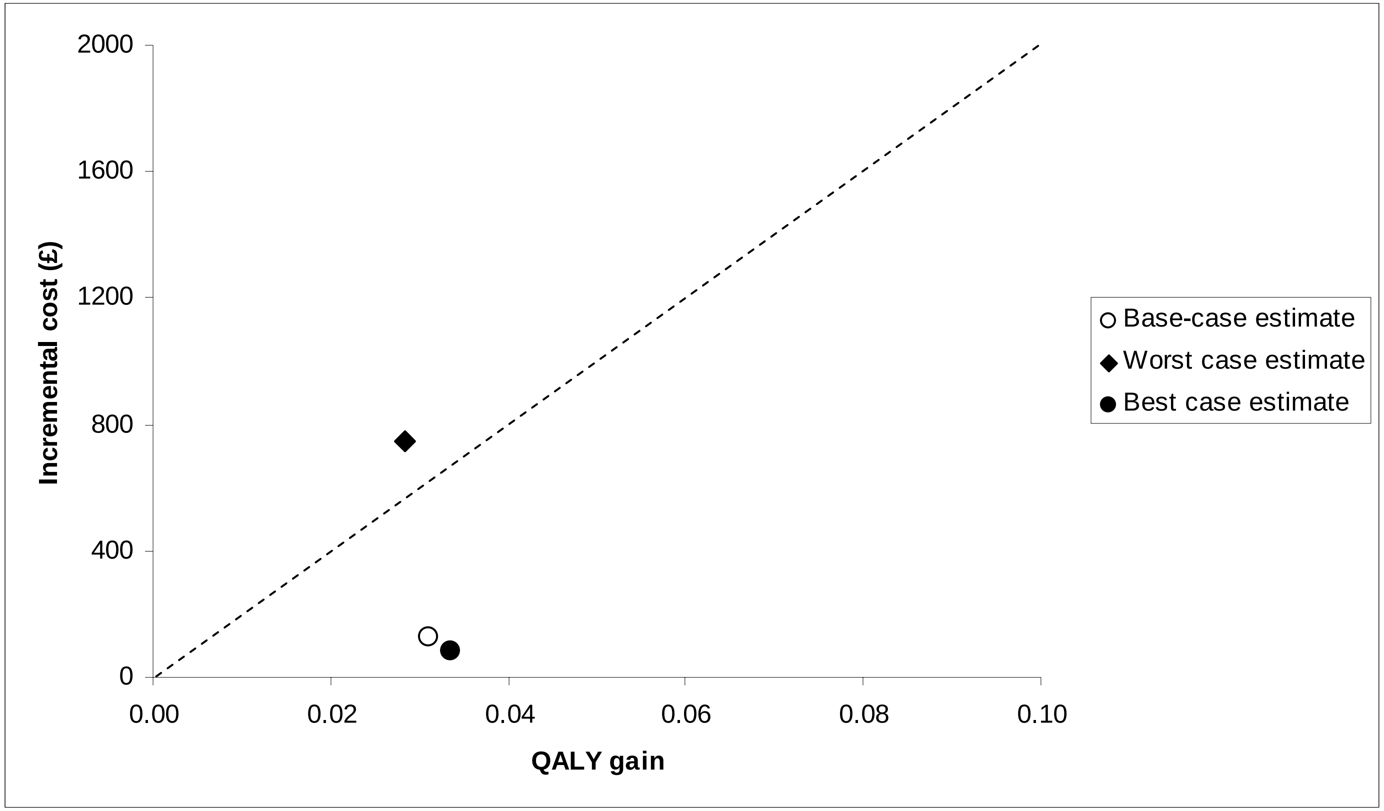


Figure 2. Estimates as to the cost-effectiveness of dance classes.

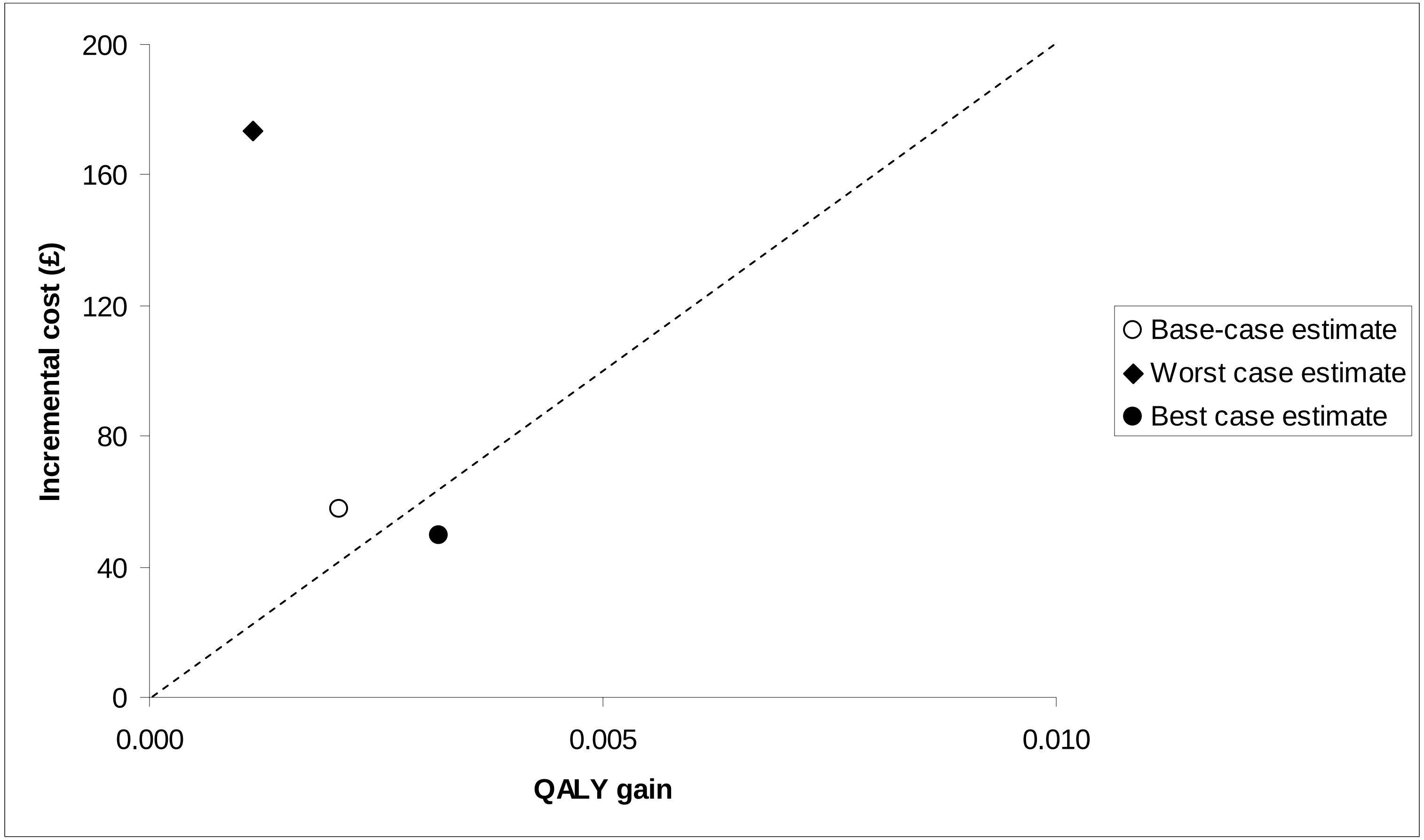
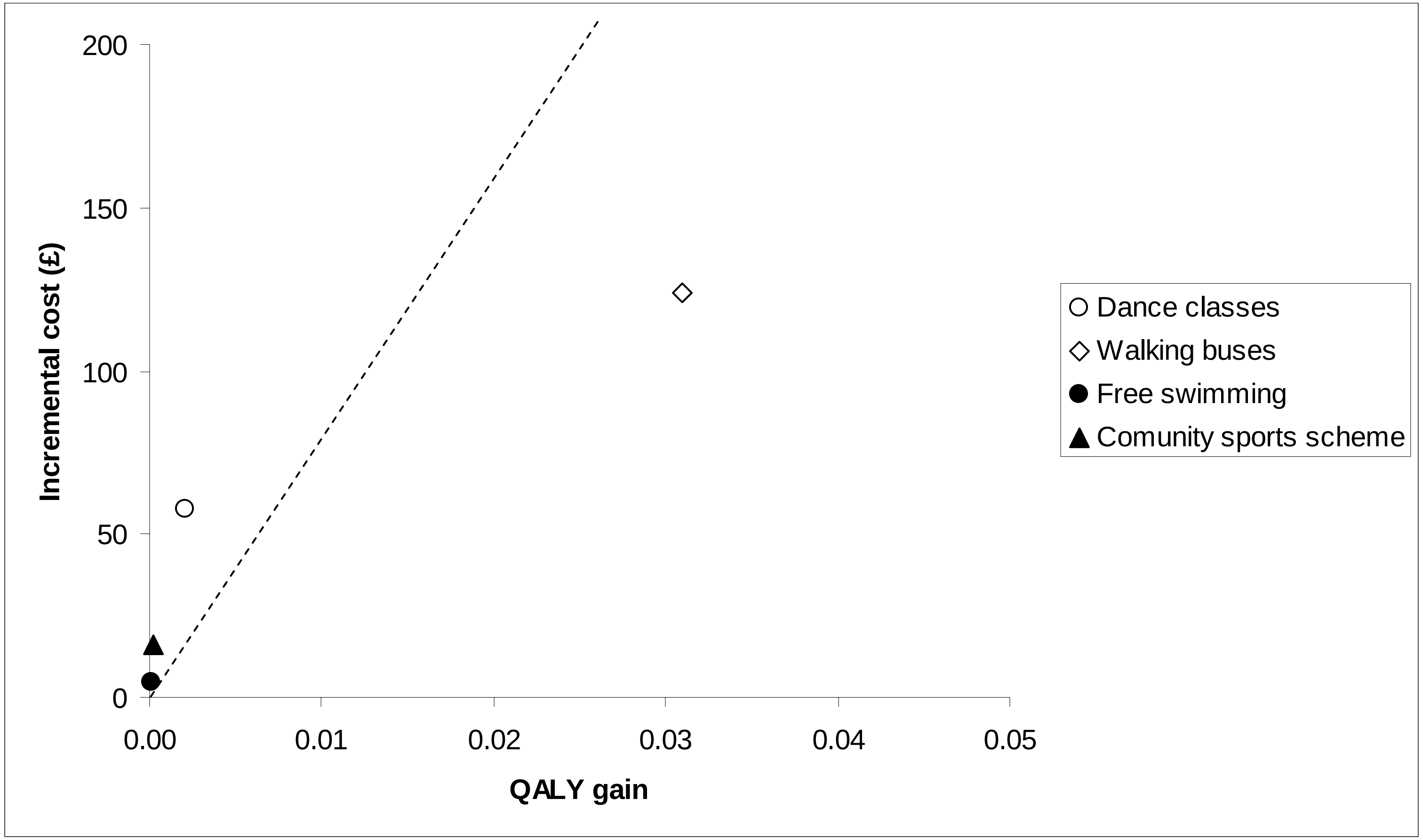


Figure 3. Cost-effectiveness estimates of i) walking buses, ii) dance classes, iii) free swimming, and iv) community sports schemes.



It should be noted that the incremental cost and QALY gain have been estimated on a per child basis for walking buses, and dance classes, whereas these variables have been calculated on a per attendance basis for free swimming and community sports schemes (see text for further explanation).

Acknowledgments

We wish to thank the following people who have helped us so willingly and enthusiastically with providing information on these interventions. Namely, Tim Hetherington and Barry Causer (Southwark Council), Charlotte Lawson (Plymouth City Council), Prof. Andy Pringle (Leeds Metropolitan University), Suzanne Priest (National Dance Teachers Association) and Lucy Frazer (Hampshire Dance) and Paul Stonebook, (Department of Health).

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