DEGREE PROJECT

Health Economic Evaluations on interventions promoting physical activity among children and adolescents

A literature review

Johanna Olofsson

Economics, bachelor's level
2020

Luleå University of Technology
Department of Business Administration, Technology and Social Sciences

ABSTRACT

Physical activity among children and adolescents around the world is decreasing and will imply negative effects on their current and future health, which also contributes to higher costs for the society. Interventions promoting physical activity among youths could increase their physical activity and, at the same time, reduce the costs for society. The purpose of this study is to evaluate interventions for increased physical activity targeted towards children and adolescents from a health economic perspective. The results indicate that there exist different types of interventions and that the choice of health economic evaluation method differs widely between studies. In order for policymakers to choose the most effective interventions that allocate the society's scarce resources in the best way, there is a need for a more streamlined methodological approach for health economic evaluations of the interventions that promote psychical activity among children and adolescents.

SAMMANFATTNING

Fysisk aktivitet minskar bland barn och ungdomar runt om i världen och kan medföra negativa effekter på deras nuvarande och kommande hälsa, vilket också bidrar till högre kostnader för samhället. En intervention som främjar fysisk aktivitet bland barn och ungdomar, kan öka den fysiska aktiviteten och samtidigt minska samhällets kostnader. Syftet med denna studie är att utvärdera interventioner som främjar fysisk aktivitet riktad mot barn och ungdomar ur ett hälsoekonomiskt perspektiv. Resultaten indikerar att det finns olika typer av interventioner och att valet av hälsoekonomisk utvärdering skiljer sig mellan interventioner. För att beslutsfattare ska kunna välja de mest effektiva interventioner som fördelar samhällets knappa resurser på bästa sätt finns det ett behov av gemensamma tillvägagångssätt i hälsoekonomiska utvärderingar på interventioner som främjar psykisk aktivitet bland barn och ungdomar.

ACKNOWLEDGEMENTS

I would like to take the opportunity and express my greatest gratitude to my supervisor Kristina Ek, that has guided me throughout this thesis with her valuable opinions and expertise. I would also like to thank my opponents for their valuable discussions during the seminars.

My sincere thanks to all the students that I have gotten the opportunity to meet and work with throughout these years at the Luleå University of Technology. Finally, I would like to thank my family for their endless support.

____

Johanna Olofsson

TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

CHAPTER 1 – INTRODUCTION

1.1 BACKGROUND

The positive benefits that regular physical activity has on physical, social, and mental health are well documented, and this knowledge has been available since the 1950s (Gc V.S. et al., 2019; Kohl et al., 2012). But even though there is plenty of knowledge about how physical activity increases the health of people, the world is facing a substantial reduction in physical activity (Geidl et al., 2020). 23% of the adults around the world do not meet the recommendations from the World Health Organization to have at least 150 minutes of moderate-intensity physical activity per week (World Health Organization [WHO], 2020).

Insufficient physical activity is a leading risk factor for noncommunicable diseases, also known as chronic diseases, such as cardiovascular diseases, cancers, chronic respiratory diseases, and type 2 diabetes (WHO, 2020). According to a study made by Lee et al. (2012), the physical inactivity accounts for 6-10% of the major noncommunicable diseases, and if this inactivity could be eliminated, the world's population could face a higher life expectancy by approximately 0.68 years.

Regular physical activity among adolescents may contribute to essential health benefits also in adulthood, active children are more likely to be active adults and children that live with obesity have a bigger risk to be overweight when they are adults (Kestilä et al., 2015; Breheny et al., 2020; Gc V.S. et al., 2019). The World Health Organization has formulated specific global recommendations on youths' minimum level of physical activity for health because of its psychological benefits for young people. WHO recommends that children and youths aged 5-17 should have a daily 60 minutes moderate- to vigorous-intensity physical activity (WHO, 2011) but despite these recommendations, 85% of the girls and 75% of the boys in Europe do not fulfill these recommendations which contribute to noncommunicable diseases (Messing et al., 2019).

The current physical inactivity is estimated to stand for 1.5% - 3.0% of global health care costs (Sutherland et al., 2016). The increasing physical inactivity among younger people places a significant burden on healthcare budgets and the total economy (Gc V.S. et al., 2019), therefore interventions in promoting physical activity could increase the physical activity and also decrease health care costs (Laine et al. 2014). According to the WHO (2019) *"A health intervention is an act performed for, with or on behalf of a person or population whose purpose is to assess, improve, maintain, promote or modify health, functioning or health conditions."*. The implementation of an intervention that promotes physical activity requires however also resources, and given that the society faces limited resources, these interventions should be economically evaluated (Lehnert et al., 2012). In order to allocate these resources efficiently (Lehnert et al., 2012), the appearance of health economic evaluations have emerged (Public Health Agency of Sweden, 2019).

According to the Public Health Agency of Sweden (2019) (own translation) *"Health economics analyzes the health and healthcare from an economics perspective and is therefore a discipline within the subject economics. Given that the society faces limited resources and increasing demand on health care, it needs to exist methods that could make priorities within the healthcare sector."*

It is essential that interventions are effective but also cost-effective in order for policymakers to make the best resource allocation decisions and increase the welfare (Kesztyüs and Steinacker, 2017; Brown et al., 2019). When an intervention is being cost-effective, the effects on the physical activity are accompanied by reasonable costs. The policymakers need to weight the costs for the intervention against the health benefits, in order to maximize the net health gains, before the implementation of an intervention because of the existing limited resources (Gc V.S. et al., 2019).

1.2 PURPOSE

The increasing physical inactivity among children and adolescents will imply negative effects on their current and future health, which also contribute to higher costs for the society. Given the existing limited resources, these costs will be a burden, and therefore interventions that promote physical activity could increase the children and adolescent physical activity and, at the same time reduce the costs for the society. It is desirable that interventions are cost-effective. The purpose of this study is to evaluate interventions for increased physical activity targeted towards children and adolescents from a health economic perspective. The analysis will focus on:

a) whether there are differences with regard to costs and benefits across different types of interventions and,
b) whether the choice of health economic evaluation method affects the outcome in terms of the cost effectiveness of an intervention.

1.3 DELIMITATIONS

This literature review will lay its focus in finding studies that investigate interventions that promotes physical activity among children and adolescents aged <20 years, all other interventions that targets people with an age >20 years are excluded. The economic evaluations should consist some form of outcome measurement that could capture the effect on the physical activity as well as the costs for the interventions. To find relevant publications, studies published between January 2006 and May 2020 is considered for inclusion.

1.4 METHOD

The chosen method for this study is to do a literature review. In order to find relevant studies, a systematic literature search was conducted between April 2020 and May 2020 in the following databases: Scopus, Google Scholar and EBSCOhost. The studies identified were further assessed on the following criteria: (1) the aim of the interventions was to promote physical activity, (2) contain some form of outcome measure that catches the change in physical activity and the costs included, (3) both the costs and effects of the interventions were evaluated, (4) they should contain some form of analysis of the effects in relation to the costs, and (5) the target group of the studies were children and/or adolescents, was required.

In total, there were thirteen studies that fulfilled the inclusion criteria. One of the most common cause of exclusion was that the interventions were aimed at elderly people or adults. For the included studies, the overall results and economic evaluations of each study will be presented and further analyzed, based on, for instance, their outcome measurement and time horizon.

1.5 DISPOSITION

This study contains five chapters, the next chapter includes the theoretical framework that constitute the basis for health economic evaluations. In Chapter 3, the methodology for how the relevant studies are included is explained. The included studies are assessed and compared in Chapter 4. Finally, Chapter 5 includes a discussion based on the results from the analysis studies and some overall conclusions for this literature review are drawn.

CHAPTER 2 – THEORY

This chapter explains briefly what a health economic evaluation is and how it assesses the interventions. Three different types of health economic evaluations are described, and finally, a short introduction to sensitivity analysis that are often applied together with health economic evaluations is presented.

2.1 THE ASSESSMENT OF AN INTERVENTION

In order to choose interventions that promote physical activity and at the same time use scare recourses in the best way, interventions should be evaluated both with regard to their effects on physical activity and with regard to their costs (Abu Omar et al., 2017). Most of the evaluations focus on the health outcomes (the effect from physical activity), but because interventions also require resources, the costs of the interventions also need to be assessed. Health economic evaluations consider both the benefits, the health outcomes, and the costs of the intervention in order to find the intervention that uses the limited resources in the best way (Sefton et al., 2002). The different outcomes that an intervention could have can be shown in an evaluation box (Svensson, 2019).

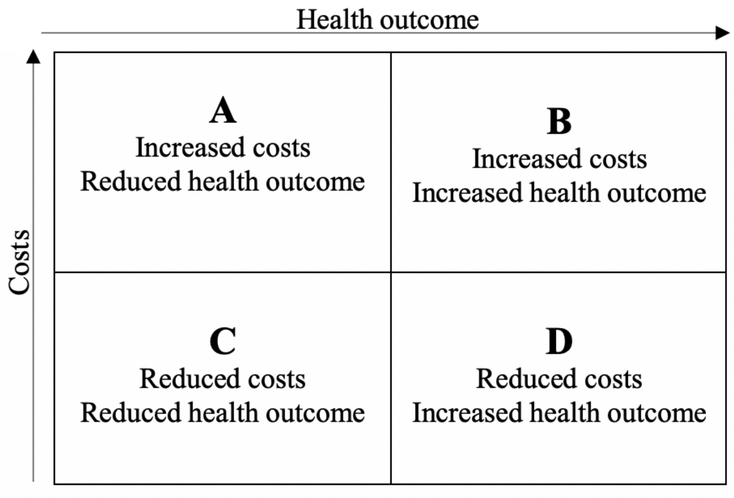

FIGURE 1. EVALUATION BOX

Source: Svensson (2019)

If an intervention ends up in alternative A, no evaluation is necessary to decide that the intervention should not be implemented, and if an intervention results in D, the intervention should be interpreted without any health economic evaluation. However, when an intervention implies higher costs and improved health, alternative B, policymakers need to weigh these outcomes against each other. If an intervention ends up in C, the policymakers also need to make an assessment of the reduced health in relation to the reduced costs (cost savings could for instance facilitate another intervention). Nevertheless, this box indicates that, alternative D would be the most attractive alternative, lowering costs and increasing health outcomes (Svensson, 2019).

Health economic evaluations can also include a comparison between two or more interventions. If an intervention is considered to be interpreted, there is a need for a comparison between the new and the existing intervention, in their costs and the effects on the health outcomes. A new intervention could be more effective in the health outcomes but have a higher cost or have a lower cost but not as high health outcome. In the table below, there are several alternatives that could arise from the comparison of different interventions (Swedish Agency for Health Technology Assessment and Assessment of Social Services [SBU], 2017a).

TABLE 1: THE ALTERNATIVES IN COMPARING INTERVENTIONS

The new intervention, compared with the existing intervention	*Lower effect*	*Equal effect*	*Higher effect*
Lower cost	1. Unclear	4. Choose the new intervention	7. Choose the new intervention
Equal cost	2. Keep the existing intervention	5. The interventions are equivalent	8. Choose the new intervention
Higher cost	3. Keep the existing intervention	6. Keep the existing intervention	9. Unclear

Source: SBU (2017a)

With the alternatives 2, 3, and 6, the existing intervention should still be used, but with the alternatives 4, 7 and 8, the new intervention should be evaluated.

2.2 HEALTH ECONOMIC EVALUATIONS

2.2.1 COST-BENEFIT ANALYSIS (CBA)

The Cost-Benefit Analysis (CBA) measures both the effects and the costs in monetary terms, meaning that this method places a monetary value on health outcomes and on the resources used. Since this method measure the change in monetary terms it could give quite a direct indication about whether an intervention is profitable from a societal perspective (Svensson, 2019). CBA is founded in welfare theory, to measure and value the effect of a policy change (Frew, 2017). This method is often difficult to apply to evaluate health effects because of the methodological challenges, trying to value interventions health outcomes in monetary terms may for instance collide with ethical and practical considerations (SBU, 2017a). Another challenge with CBA is that within healthcare there exists market failures within healthcare sector, implying for instance, that preferences are not reflected in market prices (Frew, 2017).

The criteria for an intervention to be socially profitable is that the value of the benefits from the intervention exceed the costs, this will lead to the optimal solution that could exist in the welfare economic (Gold et al., 1996). Taking an example, if a new medical solution reduces mortality with 5% and applying CBA, there will be an estimation how each death averted have a value of £50 000 or £500 000 (Gray et al., 2011). The measurement in monetary terms can be obtained by estimating willingness to pay (WTP) for interventions that could increase the health outcome (Gold et al., 1996). The direct interpretation of whether an intervention or treatment is socially profitable, that is possible with this method is a strength compared to other health economic evaluation methods. With a cost-utility analysis or the cost-effective analysis there will be necessary to include some form of benchmark for what the intervention could cost to be considered cost-effective (Svensson, 2019). The weakness with this analysis is that it is often difficult to measure the willingness to pay for changed health outcomes (Svensson, 2019).

Summing up; CBA values the health outcomes in monetary terms, such as putting a value on human life (Svensson, 2019). Because of the ethical and practical limitations, this method is still not often used in health economics evaluations compared with the other methods. Zanganeh et al. (2019) found that no study applied a CBA approach in their literature review but conclude that efforts are being made to adapt methodologies to promote the use of CBA, as it could be relevant for instance for the evaluation of obesity interventions among children and adolescents.

2.2.2 COST-UTILITY ANALYSIS (CUA)

Cost-Utility Analysis (CUA) is a method that measures the costs associated with changes in the length and quality of a person's life (SBU, 2017a). CUA is often interpreted as being a cost-effective analysis in the health economics literature (Svensson, 2019), this is because the health outcome measured does not meet the criteria for what is theoretically defined as utility, that measures the effects in monetary terms. In this study, the CUA is separately explained as one of the health economic evaluations.

There are different outcome measurements for impacts on health that can be used in CUA, the most common and the most recommended is the quality-adjusted life-year (QALY) (SBU, 2017a: Sefton et al., 2002). According to Räsänen et al. (2006) *"The QALY makes it possible to express the effectiveness of health care as a combination of a change both in the length and/or quality of life."*. Quality of life is measured on a scale ranging between zero (0) and one (1), if a person has a quality of life that equals to zero (0) it means that the person's health state is equivalent to dead, and if a person have a quality of life that equals to one (1) the person has full health (Svensson, 2019).

Another relatively commonly used outcome measurement in CUA is called disability-adjusted-life-year (DALY). With DALY, one calculates the loss of a healthy life, which is the sum of future lost quality-of-life years caused by a premature death and the lost healthy years caused by a disability. The extent to how much a person suffers from a disability is measured on a scale ranging between zero (0) and one (1), if a person does not suffers from any disability it will be equal to zero (0), while it is equal to one (1) if a person suffers from a disability which is equivalent to dead. The DALY scale can be seen as a as a mirror of the scale used in QALY. The difference between QALY and DALY is that QALY measures a person's health when DALY measures the person's illness (Svensson, 2019).

Interventions that can be implemented to increase physical activity aim to give long-term effects on people's health outcomes (Gc V.S. et al., 2019). Since resources are scarce, these interventions should be evaluated in order to ensure that these resources are allocated efficiently when measures are implemented to improve people's health (Lehnert et al. 2012). The outcome measurements QALY or DALY in a study are often combined with the incremental cost-effectiveness ratio ICER, the ICER represents the cost per QALY gained or per DALY saved (Svensson, 2019). The difference between the costs in the intervention is called the incremental costs and the difference in health outcomes is called the incremental effects, the ratio between these are then referred to the ICER (Svensson, 2019). To simplify the explanation, the difference in costs between the interventions is divided by the difference in the effects of the interventions, shown in the equation below:

$$ICER = \frac{Cost_A - Cost_B}{Effect_A - Effect_B} = \frac{\Delta Cost}{\Delta Effect}$$

In other words, the ICER shows the increased costs when achieving one more unit in health outcome (SBU, 2017a).

The effect on physical activity that comes from an intervention should last over several years in order to relate the effects to QALYs gained or DALYs saved (Wu et al., 2011). To get these long-lasting effects, there is a need for long-term assumptions when assessing these outcome measurements. For the outcome measured in changed QALY or DALY, the health benefits that comes from an intervention is assumed to give continuous health functions, such as 100% maintained health benefits for the youths throughout their lifetime (Moodie et al., 2011). When there is assumed to be constant lifetime effects on the physical activity from an intervention, the costs associated with the intervention should be discounted, when the costs will occur during several years (Svensson, 2019).

To be able to evaluate if an intervention is cost-effective or not, some benchmarks need to be used. These benchmarks vary between countries. In England and Wales, the cost-effectiveness benchmark lies between £20000-30000 (SEK320000) for one QALY (SBU, 2017a). In Australia, the benchmark for one DALY saved is <$AUD50,000 (SEK340000) per DALY. In Sweden however, there is no strict benchmark as in England and Wales, but the National Board of Health and Welfare in Sweden have put up some international guidelines based on the measurement unit QALY (Socialstyrelsen, 2014). These guidelines say that if one QALY is equal to a cost below SEK100000, the cost per QALY is interpreted to be low, if one QALY is equal to a cost above SEK5000000, the cost per QALY is interpreted to be high (Socialstyrelsen, 2014). In many countries there is no specific benchmark used (Zanganeh et al., 2019).

CUA indicates how much it would cost for a person to gain one more QALY or save one more DALY. When there are interventions that promotes physical activity among children and adolescents the QALY and DALY measures are often used to evaluate if these interventions could give long-term health effects. The next method that will be described is called the cost-effective analysis. As mentioned, earlier the CUA is often referred as a cost-effective analysis because of the reason that QALY or DALY are not consistent with the conventional meaning of the term "utilities" in economics (Moodie et al., 2015).

2.2.3 COST-EFFECTIVE ANALYSIS (CEA)

Cost-Effective Analysis (CEA) is a method that measure the costs and health effects in an intervention (SBU, 2017a). In this method the previously described outcome measurements QALY or DALY could be assessed, when the CUA comes from the CEA. Another measurement in health outcome that could be used in the CEA, is the change in physical activity measured in so-called metabolic equivalent (MET)-hours, that may be more specifically related to the direct change in physical activity (Wu et al., 2011). The CEA based on MET-hours evaluates a cost-effectiveness ratio, such as the total cost for the intervention divided by MET-hours gained (Wu et al., 2011), which gives an assessment in how much one more MET-hour gained costs.

There does not exist any concrete benchmark for the outcome measurement MET-hour as it does for QALY and DALY, in order to give an estimation if an intervention is cost-effective. Wu et al. (2011) tries to estimate a benchmark for how much one MET-hour gained could cost, by estimating the medical costs for inactivity. For the adults there should be an expenditure of approximately US$0.50 –US$1.00 per MET-hour gained and for the children and adolescents 17–35 cents in US$ per MET-hour (Wu et al., 2011), for an intervention to be cost-effective. If the costs lie below Wu et al. (2011) calculated benchmarks, an intervention could be cost-saving from a public health perspective. These benchmarks are used in other studies, such as Wang et al. (2017) that uses these benchmarks as a framework for comparing the cost-effectiveness in school-based interventions. Another study that also implement these benchmarks is Laine et al. (2014) in their literature review on school-based interventions.

The CEA could include both the effects on changes in the length and the quality of a person's life (in QALY or DALY) and the direct effects that comes from physical activity (MET-hour). The results that comes from the CEA and overall from health economic evaluations, needs to take into account the uncertainty that could exists in the costs and the health effects (Svensson, 2019). Therefore, an economic evaluation should be varied with other potential variables, in order to see what happens with the sensitivity in the results (Petrou and Gray, 2005).

2.3 SENSITIVITY ANALYSIS

In every health economic evaluation, there will be some uncertainty in the results. Costs for different interventions could for instance vary but also differ over time, measurement-errors could occur or that the wrong person is testing the intervention, there are several problems that could affect the validity and reliability of the results (Svensson, 2019). Therefore, health economic studies often include sensitivity analysis, in order to describe and to some extent evaluate the sensitivity of the results to different uncertain assumptions (SBU, 2017a). In the sensitivity analysis, the included variables are varied in order to see how much the study's results could change (SBU, 2017a). If an intervention is based on unrealistic assumptions, variables that are more realistic can be included (Döring et al., 2016) to see what happens with the results. According to Döring et al. (2016) the use of sensitivity analysis within health economic evaluations is becoming more common practice.

CHAPTER 3 – METHOD

To evaluate, interventions that promotes physical activity among children and adolescents from a health economic perspective, a literature review will be conducted to summarize and gain knowledge from the existing literature.

3.1 SEARCH STRATEGY

The execution of this systematic literature search was between April 2020 and May 2020. According to the Swedish Agency for Health Technology Assessment and Assessment of Social Services (SBU, 2017b), the systematic literature search should include at least two databases for the search to cover the relevant literature. Therefore, the literature search was conducted using the following electronic databases: Scopus, Google Scholar, and EBSCOhost. To identify relevant publications, studies published between January 2006 and April 2020 were considered for inclusion. The main reason why the year 2006 was chosen under the influence of Döring et al. (2016), their published studies were between January 2004 and November 2015, because the year 2004 marks the recognition of the increasing obesity around the world and the release of the World Health Organization's (WHO) first action plan against obesity. Studies published around 2004 is unlikely to be relevant because of the developments in the health economic evaluations (Döring et al., 2016). Therefore, the year 2006 was chosen in this literature review, in order to capture more relevant studies.

Search terms linked with "AND" were "physical activity", "interventions", "cost effective", "children" and "adolescents". Search terms linked with "OR" were "QALY", "DALY" and "MET-hour". The first search includes "physical activity" and "interventions" and "cost-effective", the second search was with the other search terms, to specify even further. This search could be seen as a narrow search because the use of the word "AND", contributed to high precision with relevant literature (SBU, 2017b).

3.2 INCLUSION AND EXCLUSION CRITERIA

In the first screening (Figure 2), the titles and abstracts of the studies were skimmed through to exclude studies that were not relevant, based on their titles and abstracts. The eligible studies included interventions that promoted physical activity and that were targeting children and adolescents, so the age was restricted to <20 years. Because of society's scarce resources (Lehnert et al., 2012), these interventions should be economically evaluated. Both the costs and the effects of the intervention needs to be recognized, to ensure that these interventions use the scarce resources in an effective way for the society and at the same time increases the physical activity for children and adolescents (John et al., 2012).

The relevant studies should include a health economic evaluation of an intervention in terms of a cost-effective evaluation that measures the physical activity combined with the costs of the intervention. The outcome measurement of changes in physical activity differs. As mentioned earlier, a common measurement is quality-adjusted-life years (QALY) or disability-adjusted-life-years (DALY), studies that include these measurements need to take significant assumptions because of the long-term perspective, such as the discounting of future health benefits. Another outcome measurement that focuses more on the direct effect on the physical activity translates the time spent on physical activity to metabolic equivalent intensity levels (MET-hours) and then calculating the cost per MET-hour gained.

The aim of the intervention did not need to be a whole population, but >150 children and adolescents should at least be reached. The focus on this review is on the studies that include interventions that promote physical activity, so the focus does not need to be on any particular additional goal, such as decreasing the obesity in children and adolescents. The potential studies require to be written in English or Swedish, these restrictions were necessary because of the author's language competencies. In summary, the chosen studies in this review needed to fulfill the following criteria: (1) the aim of the interventions was to promote physical activity, (2) contain some form of outcome measure that catches the change in physical activity and the costs included, (3) both the costs and effects of the interventions were evaluated, (4) they should contain some form of analysis of the effects in relation to the costs, and (5) the target group of the studies were children and/or adolescents, was required.

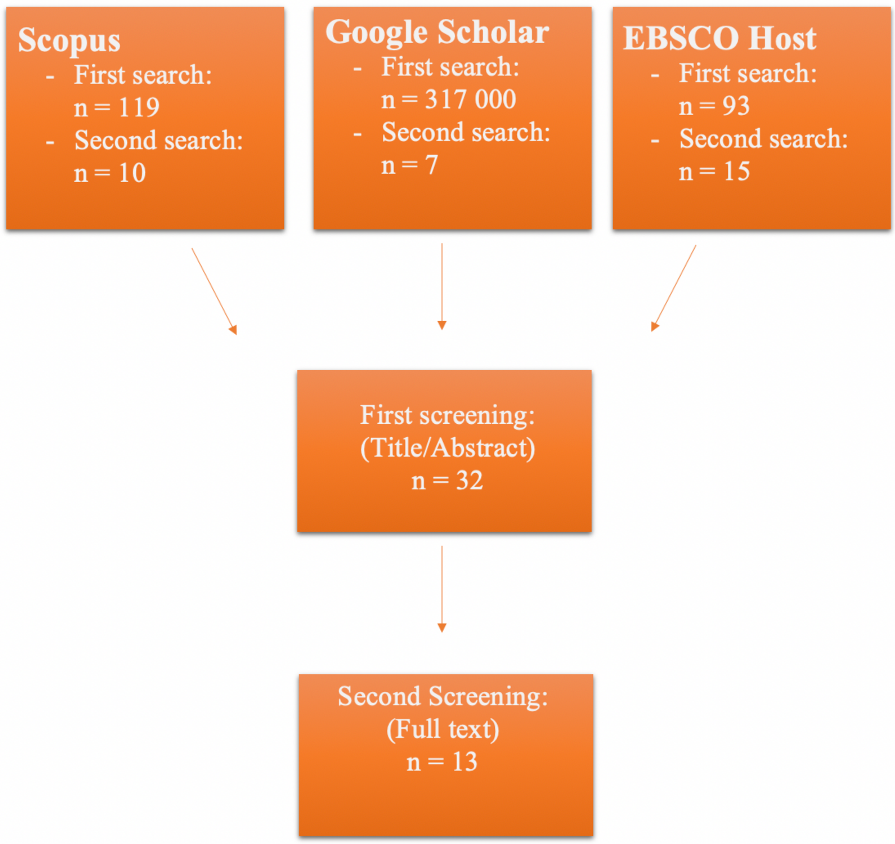

FIGURE 2. FLOWCHART

3.3 STUDY SELECTION AND DATA EXTRACTION

The second screening evaluated full-text articles and could eliminate the studies that did not fulfill the inclusion criteria. Following the flow chart (Figure 2), thirteen studies could be included in this systematic review. The selected studies were read thru and assessed by one researcher. The Consensus on Health Economic Criteria (CHEC) (Evers et al., 2005) has developed a criteria list (CHEC-list) for the assessment of the methodological quality of economic evaluations in systematic reviews. This criteria list aims at clinical trials, such as randomized controlled trials (RCT). Studies that conduct randomized controlled trials randomly divide the participants in one group that implements an intervention and one control group that does not implement an intervention (SBU, 2017c). One prerequisite with using RCT is that the participants between the groups should be approximately equal, such as in their health and the year of age, the benefit with this randomization is that the difference between the groups shall with a high probability depend on the implemented intervention (Svensson, 2019). Studies that apply RCT often include relatively short time horizons because of the significant high costs associated with implementing RCT (Svensson, 2019). In this systematic review, there is no requirement for clinical trials.

To validate the quality of the included studies, a reformed criteria list of the CHEC-list was developed by Laine et al. (2014), which could be applied to this systematic review, this criteria list does not have a requirement on RCTs. The criteria list developed by Laine et al. (2014) contains 15 questions (Table 2), the quality of each study is based on dichotomous quality scores (1 or 0) and then summed up on a total quality score (range 0-15). This criteria-list aims to state the methodological quality that each of the included studies possesses.

The following criteria classify each of the study's quality: (1) Was the study population clearly described? (Country, target population, number of participants), (2) Was the year of the calculation of costs clearly described?, (3) Was the chosen time horizon appropriate to include relevant consequences (physical activity)?, (4) Was the chosen time horizon appropriate to include relevant costs?, (5) Were PA outcomes measured appropriately? (Time-frequency, amount, all these), (6) Were PA outcomes measured objectively?, (7) Was the used effectiveness data source suitable for evaluating the PA effects on the target population?, (8) Was there a control/comparison group or comparison to no intervention situation, or before/after measurement?, (9) Were all intervention costs valued appropriately?, (10) Were all future costs identified appropriately?, (11) Were all future PA outcomes identified appropriately?, (12) Were all future intervention costs discounted?, (13) Were all important PA variables, whose values are uncertain, appropriately subjected to sensitivity analysis?, (14) Were all important cost variables, whose values are uncertain, appropriately subjected to sensitivity analysis?, (15) Does the study discuss the generalizability of the results to other settings and population groups?.

TABLE 2: QUALITY SCORES OF THE ARTICLES INCLUDED IN THE PRESENT REVIEW*

	CHEC-list	Wang et al.	Sutherland et al.	Babey et al.	Cradock et al.	Breheny et al.	Brown et al.	Gc V.S. et al.	Canaway et al.	Pringle et al.	Moodie et al. (2009)	Haby et al.	Moodie et al. (2011)	Moodie et al. (2013)
1.	Was the study population clearly described? (Country, target population, number of participants)	1	1	0	0	1	1	1	1	1	1	1	1	1
2.	Was the year of the calculation of costs clearly dscribed?	1	1	1	1	1	1	1	1	1	1	1	1	1
3.	Was the chosen time horizon appropriate to include relevant consequences (physical activity)?	1	1	1	1	1	1	1	1	1	1	1	1	1
4.	Was the chosen time horizon appropriate to include relevant costs?	1	1	1	1	1	1	1	1	1	1	1	1	1
5.	Were PA outcomes measured appropriately? (Time frequency, amount, all these)	1	1	1	1	1	1	1	1	1	1	1	1	1
6.	Were PA outcomes measured objectively?	1	1	1	1	1	1	1	1	1	1	1	1	1
7.	Was the used effectiveness data source suitable for evaluating the PA effects on target population?	1	1	1	1	1	1	1	1	1	1	1	1	1
8.	Was there a control/comparison group or comparison to no intervention situation, or before/after measurement?	0	1	0	0	1	1	0	1	0	0	0	0	0
9.	Were all intervention costs valued appropriately?	1	1	1	1	1	1	1	1	1	1	1	1	1

10.	Were all future costs identified appropriately?	1	1	1	1	1	1	1	1	1	1	1	1	1
11.	Were all future PA outcomes identified appropriately?	1	1	1	1	1	1	1	1	1	1	1	1	1
12.	Were all future intervention costs discounted?	1	1	1	1	1	1	1	1	1	1	1	1	1
13.	Were all important PA variables, whose values are uncertain, appropriately subjected to sensitivity analysis?	1	1	0	1	1	1	1	1	0	1	1	1	1
14.	Were all important cost variables, whose values are uncertain, appropriately subjected to sensitivity analysis?	1	1	0	1	1	1	1	1	0	1	1	1	1
15.	Does the study discuss the generalizability of the results to other settings and population groups?	1	1	0	1	1	1	1	1	1	1	1	1	1
	Total quality score; Maximum 15	**14**	**15**	**10**	**13**	**15**	**15**	**14**	**15**	**12**	**14**	**14**	**14**	**14**
	*PA indicates physical activity													

Source: Laine et al. (2017)

The total quality score that each of the studies received did not influence the inclusion of the studies, only an approximation in the strength of the studies evidence (Laine et al., 2017; Wu et al., 2011). The difference between the CHEC-list developed by the Consensus on Health Economic Criteria and the reformed CHEC-list by Laine et al. (2017), is four additional questions included, question 2 and 6-8. These added questions contribute to a better comparison of the quality of these kinds of literature reviews that do not only include studies with clinical trials, such as RCT. Overall, the included study's total quality score ranges between 10-15, which indicates high quality and also that the quality of each study is similar to each other.

CHAPTER 4 – RESULTS

A total of 317212 studies were identified from the search of Scopus, Google Scholar, and EBSCOhost. Figure 2 displays the selection process to find relevant studies in a flowchart. The most common exclusion criteria were that the interventions were aimed at elderly people or adults. Some articles did not have a specific outcome measure in terms of cost-effectiveness and were therefore also excluded. The following chapter summarizes the results from the literature search.

4.1 GENERAL CHARACTERISTICS

In total, thirteen studies met all the inclusion criteria. Eight of the included studies focus on interventions promoting physical activity among children and adolescents, and the remaining five focused on interventions that were aimed at preventing obesity trough increased physical activity among children and adolescents. The majority (n=5) of the included studies were conducted in Australia, four studies were made in the United States (USA) and the last four in the United Kingdom (UK).

TABLE 3: ARTICLE SUMMARY

Author/Year/Country	Intervention	Economic Evaluation/Target	Outcome measure/Perspective/Time horizon	Costs	Results
Sutherland et al. 2016 (Australia)	Multicomponent intervention, reduce the decline in PA (Physical Activity for Everyone) School- and community-based	Cost-Effective Analysis (CEA) Randomized control trials (RCT) 1150 students in grade 7 in Australian schools	MET-hour gained Societal perspective 24 months (2 years) BMI Sensitivity Analysis	Total cost for the intervention in the Australian dollar ($329,952). Includes personnel costs, material costs, and printing. Exclude costs for research and development. (Costs AUD$ in 2014)	Cost AUD$394 (SEK 2594 in 2020)/student in the intervention group AUD$1 (SEK6.75)/MET hour gained/ person/day. Cost-effective
Babey et al. 2014 (USA)	After-school program Before-school program PE classes and extended day PE In-class breaks School-based	CEA 30 students/class	MET-hour gained School year length of 180 school days	Total cost for intervention per participating child Includes personnel costs, materials, equipment, program overhead costs. Exclude costs for research and development (Costs US$ in 2012)	**-In-class breaks**: $0.01 (SEK 0.07) MET-hour gained -Before-school program: $0.49 (SEK 3.53) MET-hour gained **-Longer day, daily PE:** $0.98 (SEK 7.04) MET-hour gained -After-school program: $10.62 (SEK 76.40) MET-hour gained Cost-effective

Cradock et al. 2017 (USA)	Active PE Active School Day Active Recess Healthy Afterschool New Afterschool Hip Hop to Health jr. School-based	CEA Ranged from 90 000 youth to 31.3 million depending on the intervention	MET-hour gained Societal Perspective 10 years reach of the intervention (2015-2025) Sensitivity Analysis	Total cost of national implementation of each intervention Health care costs $220 for children aged 6-19 years (Costs US$ in 2014)	**Afterschool sector:** New after-school – cost saving Health Afterschool - $3.14 (SEK 22.95) MET-hour gained **School sector:** Active Recess - $0.16 (SEK 1.16) Active PE - $0.23 (SEK 1.68) Active School day - $1.05 (SEK 7.67) Hip Hop - $0.13 (SEK 0.95) Cost-effective
Wang et al. 2017 (USA)	Ready for Recess Increase PA School-based	CEA 445 children in grades 3-5 Benchmark, according to Wu et al.	MET-hour gained One school year Sensitivity Analysis	Total intervention costs Includes personnel costs, equipment, and initial training costs. Excludes research and development costs (Costs US$ in 2008)	$0.32 (SEK 2.72) MET-hour gained Cost-effective
Breheny et al. 2020 (UK)	The Daily Mile School-based Increase PA	Cost-Utility Analysis (CUA) RCT 18 intervention schools (n=850) and 19 control schools (n=820)	QALY gained 12 months BMI z-score Sensitivity Analysis	Total intervention costs (Costs GBP in 2017)	£7455 (SEK98980,92)/QALY gained, cost-effective for girls, and overall 76%. No big effect on the BMIz

		Benchmark: <£20000 QALY			
Brown et al. 2007 (USA)	CATCH-intervention School-based Prevent obesity	CUA RCT Intervention schools (n=423) and control schools (n=473) Benchmark: <$30000 QALY	QALY gained Societal Perspective During the years 2000-2002 Sensitivity Analysis	Total intervention costs Include Medical Costs due to obesity (Costs US$ in 2004)	$900(SEK 7904.32) /QALY gained Cost-effective
Gc V.S. et al. 2019 (UK)	After-school intervention Multicomponent intervention Increase PA School- and community-based	CUA Benchmark: <£20000 QALY 10 000 healthy adolescents	QALY gained Time horizon: 65 years, so the model follows the cohort of 16 years old until they reach 81 years Sensitivity Analysis	Total intervention costs (Costs GBP in 2014)	After school: 0.004 QALY gained £11486 (SEK 138124) /QALY, 59%, Cost-effective Multicomponent: 0.002 QALY gained £68056 (SEK818402), 8%, Cost-effective
Canaway et al. 2019 (UK)	Multicomponent intervention: Aimed to increase physical activity by 30 minutes per day and encourage healthy eating. School-based, obesity prevention	CUA RCT 54 schools (n=1467) Benchmark: <£30000 QALY	QALY gained Time horizon: 12 months Sensitivity Analysis	Total intervention costs (Costs GBP in 2014)	0.006 QALY gained £26815 (SEK 322461)/QALY 52% Cost-effective Uncertain measure

Pringle et al. 2010 (UK)	Campaigns Exercise classes Exercise referral Motivational interviews Outdoor activity Peer-mentoring Training physical activity leaders. Prevent physical inactivity Community-based	CUA Benchmark: <£20000 QALY Intervention reached 1051	QALY gained Time horizon: 2004-2006	Total intervention costs Included personnel, training, premises, transport, equipment, publicity, and other running costs Exclude the indirect costs to partner agencies or the costs to participants (Costs GBP in 2003)	Cost per QALY ranged from £47-£506(SEK 743.83-8007,94)/QALY All interventions were cost-effective
Moodie et al. 2009 (Australia)	Walking School Bus School- and community-based Prevent physical inactivity and obesity	CUA Benchmark: <$50000 DALY Intervention reached 7840 children	DALY Societal perspective Time horizon: the year 2001 Sensitivity Analysis	Total intervention costs Exclude research and development costs (Costs AUD$ in 2001)	$0.76M (SEK 5M)/QALY Not cost-effective Needs more interventions to promote active transport
Haby et al. 2006 (Australia)	13 potential obesity prevention interventions Community-based	CUA Intervention reached 6940 children	DALY Time horizon: 2004-2006 Sensitivity Analysis	Total intervention costs (Costs AUD$ in 2001)	Biggest population impact: Reduction of TV-advertising of high fat /and or high sugar foods The biggest impact on BMI: Laparoscopic adjustable gastric banding Walking School Bus – not cost-effective (30 DALYs saved)

Moodie et al. 2011 (Australia)	TravelSmart Increase active transport and prevent obesity School- and community-based	CUA Benchmark: <$AUD50,000 per DALY Intervention reached 267700 children	DALY Societal perspective Time horizon: 2001 Sensitivity Analysis	Total intervention costs Exclude research and development costs (Costs AUD$ in 2001)	95 DALYs saved and $AUD117000 (SEK 781288) per DALY Not cost-effective
Moodie et al. 2013 (Australia)	Be Active Eat Well Promote healthy eating and physical activity School- and community-based	CUA Benchmark: <$AUD50,000 per DALY Intervention reached 181,212 children across 656 schools	DALY Societal perspective Time horizon: 2003-2006 Sensitivity Analysis	Total intervention costs Exclude research and development costs (Costs AUD$ in 2006)	10.2 DALYs saved $AUD29798 (SEK206639) per DALY In total: 82,899 BMI units and 1521 DALYs. Cost-effective

With regard to study design, among the thirteen studies included, four were based on randomized control trials (RCT), i.e. they use a control group that does not implement the intervention. As mentioned earlier, this means that a comparison between the groups can be made to evaluate program effectiveness. The studies in this literature review that do not use an RCT conclude that their results should be interpreted carefully, due to the absence of a control group, such as Wang et al. (2017) who state that the robustness of their results may be limited due to the lack of a control group.

Table 3 gives an overview of the thirteen included studies and their interventions, including the chosen methods for economic evaluations, and their main results. The included studies are based on two methods for economic evaluation, the cost-effective analysis (CEA) and the cost-utility analysis (CUA). As mentioned earlier, the CUA is a variant of the CEA method. In the review, the CUA studies principally allow a separation of the outcome measurement and its impact on QALY or DALY. Four studies use the cost-effective analysis (CEA) based on the outcome on physical activity, by using the outcome measure MET-hour. The other nine studies use the cost-utility analysis (CUA) with the outcome measured on QALY or DALY.

The studies (n=4) that use the outcome measure MET-hour, evaluate the outcome with regard to physical activity in relation to the short-term costs associated with the interventions. The other studies (n=9) evaluate the outcome based on changes in QALY or DALY, that is, effects that mainly can be excepted more in a longer-term perspective. Cradock et al. (2017) focus at the program effects for 10 years and Gc V.S et al. (2019) study a hypothetical cohort of adolescents aged from 16 years old until they reach 81 years (time horizon 65 years). These two studies are the only that takes a longer time perspective in their evaluations. Studies that focus on the effects of an intervention in the long-term, measure the current effects (on the physical activity) and the costs associated when implementing an intervention and then simulate these effects in the long-term perspective. So, studies that are based on a longer time horizon do not measure the effects throughout the time horizon, instead they measure the effects in the short-term and then simulate the effects to a longer perspective. Other studies study the effect of an intervention for between 1-3 years and do not simulate the effects in a longer perspective.

4.2 TYPES OF INTERVENTION PROGRAMMES

All the interventions that are included in this review aim to increase physical activity among children and adolescents, while the settings in these studies differ. Most (n=6) of the studies are school-based and focuses on implementing interventions in schools. Two studies focus on interventions that could reach a whole community and the remaining five focus on interventions that are both school- and community based. Overall, the number of children and adolescents reached by the interventions varies substantially, ranging from 445 youths to 31.3 million youths reached, depending on the studies perspective and intervention programme.

Five studies use multicomponent interventions that combine different health related activities, such as increasing the physical activity together with healthier eating. After-school interventions, that promote physical activities after school, are analyzed in three studies. Another type of intervention, which costs and benefits are studied, that is included in the review is the promotion of active school transport modes, such as walking or bicycling to school, three studies focus at these types of interventions. The impacts of extended school days and more physical education (PE) classes are evaluated by four studies and active recess during school days is evaluated by two studies.

4.3 COST ESTIMATES

The total cost estimates for these interventions are included in all the studies. For the CEAs of interventions according to the recommendations (Anderson, 2010) establishment costs (such as costs for research and development) should be excluded. The studies in the review are in line with these recommendations. Some of the studies (n=6) take a societal perspective on their costs, they include the costs of the healthcare sector, households and costs falling on other sectors involved in the implementation of the intervention.

Table 3 displays the results of the economic evaluations, there is a wide range of costs. The costs in the studies included in this literature review are calculated in three different currencies: US dollars, British pounds and the Australian dollars. In order to make a comparison between these costs, all currencies are translated to the Swedish currency

SEK[1] and then adjusted to today's (2020) price level[2]. For example, the study made by Brown et al. (2007) calculate costs in US dollars 2004, the value of the Swedish currency in US dollar in 2004 is calculated and then adjusted to the current Swedish price level. These results can be seen in table 3, in order to make comparison between the studies and respective intervention.

4.4 COST-EFFECTIVENESS RESULTS

To be able to conclude if an intervention is cost-effective or not, there are different benchmarks defining how much an intervention could cost to be considered cost-effective. For the outcome measured in MET-hours gained, some studies use the calculated benchmark of Wu et al. (2011), while others, like Sutherland et al. (2016), compare with other similar studies based on the same interventions to determine if the intervention studied is cost-effective. For the outcome measured in changes in QALY or DALY there are different benchmarks available depending on which country the intervention is implemented, in table 3 the different benchmarks are presented for each study.

4.4.1 MULTICOMPONENT INTERVENTIONS

The results of the five studies promoting increasing physical activity among children and adolescents by implementing multicomponent interventions differ across the studies regarding time-horizon. All studies except Gc V.S et al. (2019) use a short time horizon of 1-3 years. Canaway et al. 2019 implement an intervention with the shortest time horizon (12 months) and is the only short-term study that found a multicomponent intervention that was not cost-effective (with only 52% chance to be cost-effective). Gc V.S et al. (2019) long-term horizon on the multicomponent intervention, had only 8% chance to be cost- effective.

Sutherland et al. (2016) use the outcome measurement MET-hours in their study of a multicomponent intervention. They report a cost of SEK6.75/MET-hour gained. The

[1] https://www1.oanda.com/fx-for-business/historical-rates

[2] https://www.scb.se/hitta-statistik/sverige-i-siffror/prisomraknaren/

studies using the outcome measurement QALY, reach the conclusion that QALY improved within the range 0.002 – 0.006 but with costs ranging between SEK7904.32 – SEK818402. Moodie et al. (2013) use the outcome measurement DALY and report 10.2 DALYs saved with costs corresponding to SEK206639/DALY. Overall, the results of the studies using multicomponent interventions are scattered. The outcome measures differ between the included studies and the specific benchmarks used for cost-effectiveness could differ, making the comparability between these studies difficult.

4.4.2 AFTER-SCHOOL INTERVENTION

Both Cradock et al. (2017) and Gc V.S et al. (2019) takes more of a long-time perspective (>10 years) in their evaluation of interventions including a variety of activities for youths after school, supervised by the school. When simulation for a longer term perspective, these two studies conclude that the interventions are cost-effective, resulting in substantial reductions of cases in obesity. They conclude that cheaper, more narrowly targeted interventions could give better value-for-money than the resource-intensive multicomponent interventions (Cradock et al., 2017; Gc V.S. et al., 2019).

The implementation of an after-school program during a school year is also found to be cost-effective (SEK 76.40/MET-hour gained). Even though the impact on the physical activity was relatively modest and the participation of youths was quite limited, but the need for after-school programs will remain as long as youths are in need of supervision after school (Babey et al., 2014).

4.4.3 ACTIVE SCHOOL TRANSPORT

The intervention that promotes active transport to school had a relatively short time horizon of implementation (1-2 years) and it is the only intervention that did not meet the cost-effective criteria in any of the studies (n=3). All these studies, Moodie et al. (2009), Haby et al. (2006) and Moodie et al. (2011) are studies conducted in Australia, and include interventions that are used in a project called "Assessing Cost-Effectiveness (ACE) in obesity". The ACE-obesity project is commissioned by the Department of Human Services in Victoria, Australia, with the aim to prevent obesity.

The outcome measure used for this intervention is DALY. Haby et al. (2009) motivate their use of DALY, with its capacity to capture both the morbidity and mortality effects, and with the existing information on health statuses for the included youths available for Australia. Both Moodie et al. (2009) and Moodie et al. (2011) refer to the study made by Haby et al. (2009) in their choice of the outcome measurement DALY.

Both Haby et al. (2006) and Moodie et al. (2011) report relatively low values of total DALYs saved (ranging 30-95 DALYs) with this intervention, compared to the intervention "Reduction of TV-adverting of high fat/and or high sugar foods" that was found to save up to 37000 DALYs. The costs of this intervention are clearly above the benchmarks for the corresponding outcome measures. Also, Moodie et al. (2009) and Moodie et al. (2011) report costs per DALY that lie considerably over the recommended benchmarks.

Active transportation to school does not seem to give the best effect on the physical activity and in the prevention of obesity, in relation to the costs associated with the intervention. Moodie et al. (2009) and Moodie et al. (2011) state however that this type of intervention is intended to change the behavior in transportation and because of that give positive side effects (such as safer traffic environment and less pollution arounds schools), rather than being an intervention that aims at increasing the physical activity and prevent obesity only.

4.4.4 ACTIVE RECESS

Two studies use an intervention that aims to increase the physical activity of children and adolescents during the recess in school. Wang et al. (2017) implements this intervention during one school year, it reaches 445 children in the grades 3-5. The effects of adopting a longer time horizon in this intervention is studied by Cradock et al. (2017) and estimates a national reach with over 11.3 million youths.

Both these studies use the outcome measure MET-hour. Wang et al. (2017) find a cost corresponding to SEK2.72/MET-hour gained, in a study with relatively short time horizon (for the implementation) and discuss that this intervention could probably produce a better cost-effectiveness ratio with a longer time period, which Cradock et al. (2017) looks at. By adapting a longer time horizon, the intervention costs SEK1.16/MET-hour gained (Cradock et al., 2017) which is lower than the short-term costs. Both of these studies are below Wu et al. (2011) benchmark for the cost per MET-hour gained.

4.4.5 EXTENDED PHYSICAL EDUCATION (PE)

Babey et al. (2014), Breheny et al. (2020) and Pringle et al. (2010) analyze interventions that contain some form of extended physical education in school or in the community, by implementing the intervention during a shorter time horizon (1-2 years), reaching between 800-1100 children. There are mixed results in the short-term, the implementation of a longer day in school (because of increasing physical education) is found to be cost-effective. However, the results of analyzing the implementation of the "Daily Mile", with a potential to be 76% cost-effective (Breheny et al., 2020), indicates that the cost-effectiveness only applies for the girls, the boys' results were not statistically significant. By simulating a longer-term perspective (>10years) the effects of active physical education are found to be cost-effective and could reach as many as 21.7 million youths (Cradock et al. 2017).

Two studies use the outcome measurement MET-hour and report cost-effective results on their evaluations. The remaining studies apply the outcome measurement QALY and their results differs.

4.5 SENSITIVITY ANALYSIS

In every cost-effective analysis, there will be some uncertainty in the results. Costs for different interventions could vary but also differ over time, measurement-errors could occur, there are several problems that could occur and affect the result in a negative way (Svensson, 2019). In this literature review most of the studies (n=11) conduct some form of sensitivity analysis. Wang et al. (2017) use four different scenarios in order to test the robustness of their study results, while changing the programs costs and effectiveness, the intervention remained cost-effective during all four scenarios. Haby et al. (2006) calculate their studies expected benefits, costs and cost-effectiveness ratio with a 95% uncertainty range. One of the strengths that Brown et al. (2007) claim that their study possesses, is that their results are robust to changes in their estimates.

The included studies in this review are made in different countries and context. Therefore, there is a need to generalize these results (Haby et al., 2006) trough sensitivity analysis, to evaluate whether the results of the interventions could potentially be generalized to different countries. According to Döring et al. (2016), the use of sensitivity analysis in model-based economic evaluations is becoming common practice, in order to test the uncertainty around the included parameters. Two studies in this review do however not include any form of sensitivity analysis, which is not in line with Döring et al. (2016). The risk, of not testing the sensitivity of estimated parameters and how it could affect the overall results, is that these studies interventions may not work in other countries or could not even be implemented to a real context (Haby et al., 2006).

CHAPTER 5 – DISCUSSION & CONCLUSIONS

In the final chapter, a discussion is made based on the findings from the results and some overall conclusions drawn from this literature review.

5.1 MAIN FINDINGS

This literature review includes a comprehensive summary of the existing literature on the cost-effectiveness of physical activity interventions targeting youths. The main finding in this review is that the current knowledge in the cost-effectiveness of interventions promoting physical activity among children and adolescents is scattered. There are some indications that most of these interventions are cost-effective, but there is considerable variation in the included studies regarding which type of intervention that is cost-effective. Taking a public health perspective (Abu Omar et al. 2017) on the findings in this review, the scattered results of the different interventions indicate that there is an urgent need to define more clearly which specific interventions that are cost-effective.

None of the included studies used the cost-benefit analysis (CBA) approach, which could be in line with the explanation that there are substantial methodological challenges (SBU, 2017) in measuring the health outcomes in monetary units (because of the practical and ethical reasons). The majority (n=4) of the included studies use the outcome measure MET-hour gained, six studies evaluate the outcome based on changes in QALY, and the remaining studies (n=3) applied DALY as their outcome measurement.

Gc V.S. et al. (2019) apply the most extended time horizon (>65 years), this study evaluates the outcome based on changes in QALY. Cradock et al. (2017) also implement a longer perspective (>10 years) but use the outcome measurement MET-hour instead. The study made by Cradock et al. (2017) applying MET-hour suggests that the interventions analyzed are cost-effective in the long run, while Gc V.S et al. (2019) that use QALY, suggest that the analyzed interventions barely reach the cost-effectiveness.

By looking at table 3, the studies that implement interventions during a shorter time horizon, and are using MET-hour gained, results in cost-effective interventions.

For the school-based interventions, the majority of them are profitable, except for active transportation to school that could not meet the cost-effective criteria. As mentioned earlier, Moodie et al. (2009) and Moodie et al. (2011) state that these interventions should instead promote a change in the behavior in transportation among the youths, than being an intervention that promotes physical activity and prevents obesity.

An intervention that promotes physical activities in school during recess time shows promising results of being cost-effective. This intervention remains cost-effective regardless of the time horizon, suggesting that active recess could successfully help students (Wang et al., 2017) to increase their physical activity without putting a large financial burden on the school.

5.2 METHODOLOGICAL LIMITATIONS AND CHALLENGES

Through this review, there is an appearance of several methodological limitations and challenges for future research (Abu Omar et al., 2017). The use of randomized controlled trials (RCT) is uncommon, and is only used in the studies that reach <1500 youths (more on an individual rather than population based level) and with a relatively short-term time horizon (1-2 years). In table 2, the studies that reach >1500 children and adolescents seem to have difficulties to randomly divide the participants into two groups. Moodie et al. (2013) reach 181212 children, the use of a control group that is in the same size is hard to identify but also to find groups that should be approximately equal, such as in their health and the year of age, when the numbers of participants are considerably high.

This review implies further that interventions that reach a whole population do not seem to be more cost-effective than the interventions on the individual level. Sutherland et al. (2016) conclude that their intervention "Physical Activity for Everyone" should be further evaluated to support a large-scale implementation because of the achieved cost-effectiveness in the short-term time horizon. In another similar literature review by Abu Omar et al. (2017) they find that population-level interventions have a higher potential to be cost-effective, which is not a conclusion that can be drawn in this review.

The after-school intervention has a lower reach among youths, and higher costs due to the labor needed for childcare in the after-school hours, creating a financial challenge for the schools that implements this intervention. However, the cost-offset that arises from greater efficiencies in childcare (Cradock et al., 2017), such as the direct costs for families that arise from the time spent caring for the children, may justify their higher costs. As mentioned earlier, the need for after-school programs will remain as long as youths are in need of supervision after school (Babey et al., 2014).

Another important challenge in the studies that apply the outcome measurement QALY or DALY is the need for the long-term assumptions; the youths are assumed to maintain 100% of the health benefits that come from an intervention throughout their lifetime (Moodie et al., 2011). Such lifetime benefits are unrealistic and a strong assumption because the behavioral changes that intervention measures intend to create, could be difficult to maintain (Moodie et al., 2013) and could overstate but also understate the cost-effectiveness results. Haby et al. (2006) discuss this limitation and states that if all the health benefits caused by an intervention is lost when a child reaches 25 years of age, it could result in zero DALYs saved. Furthermore, if the maintenance of the health benefits does not hold over time, the appearance of diseases attributable to physical inactivity may still occur in similar frequencies. Still, with the assumption that these health benefits remain during a lifetime, the prevalence of these diseases in the future may be underestimated (Cradock et al., 2017). Another limitation that Gc V.S et al. (2019) discusses is that the increased physical activity could contribute to more positive health benefits for the youths, such as the effect physical activity could have on reducing risk of depression.

5.3 CONCLUSIONS

The overall conclusions from this literature review together with some final discussions:

- Interventions that promote active transport to school cannot meet the cost-effective criteria.
- Promoting physical activities in school during recess time seems to be cost-effective without putting a large financial burden on the school.

Studies that contain cost-effective school-based interventions discuss the significant role school could have with these interventions. Breheny et al. (2020) state that the school is a central place to improve the physical activity and Wang et al. (2017) mention that the school plays a critical role in these interventions. By looking at the results from this review, investments in school-based interventions could be financially viable and, at the same time, increase the physical activity among the youths.

Wang et al. (2017), with the intervention "Ready for Recess," mentions that extending the effectiveness for more than one year could produce better cost-effectiveness of their intervention. Hence, cost-effective interventions with a shorter time-horizon could have the possibility to remain profitable in the longer run.

- All the studies that use the outcome measure MET-hour, regardless of the time horizon, indicate that interventions are cost-effective.
- The assumption that health benefits are maintained throughout a lifetime, required for the outcome measurements QALY or DALY, could give misleading results.
- The specific benchmarks used for cost-effectiveness differ, making comparability between the studies difficult.

One interesting finding is in the studies that measure the outcome in the amounts of MET-hours gained, provides only cost-effective results compared with studies that measure the outcome changes in QALY or DALY, that gives varying results. There does not exist any concrete explanation of why MET-hour could provide better results, but depending on which methodological approach imposed, gives shifting results. Wu et al. (2011) discuss that the use of the outcome measurement MET-hour could capture important short-term benefits, such as mood improvement, that the outcome measured in changes in QALY or DALY could miss because of their long-term assumptions. So, the direct effects that the MET-hour could measure may be an advantage in interventions that promote physical activity, because of the reason that one could measure more specific, the outcome in the physical activity. However, there is a need for a common classification of interventions and outcome measurements in order to make easier comparability. The need for conventional approaches to evaluate cost-effectiveness is something that Döring et al. (2016) and Abu Omar et al. (2017) highlights in their respective literature reviews.

- There is a need for conventional approaches to evaluate cost-effectiveness in an intervention to conduct meaningful economic evaluations.

In conclusion, the overall result from the thirteen included studies is scattered. The number of studies that investigates these types of interventions is increasing (Wu et al. 2011), and therefore, more attention should be aim at the quality of these studies and the use of a standard outcome measure. In order for policymakers to choose the most effective interventions that allocate the society's scarce resources in the best way, there is a need for a more streamlined methodological approach in health economic evaluations of the interventions that promote psychical activity among children and adolescents.

REFERENCES

Abu-Omar, K., Rütten, A., Burlacu, I., Schätzlein, V., Messing, S., & Suhrcke, M. (2017). *The cost-effectiveness of physical activity interventions: a systematic review of reviews.* Preventive medicine reports, 8, 72-78. https://doi.org/10.1016/j.pmedr.2017.08.006

Babey, S. H., Wu, S., & Cohen, D. (2014). *How can schools help youth increase physical activity? An economic analysis comparing school-based programs.* Preventive medicine, 69, S55-S60. https://doi-org.proxy.lib.ltu.se/10.1016/j.ypmed.2014.10.013

Breheny, K., Passmore, S., Adab, P., Martin, J., Hemming, K., Lancashire, E. R., & Frew, E. (2020). *Effectiveness and cost-effectiveness of The Daily Mile on childhood weight outcomes and wellbeing: a cluster randomised controlled trial.* International Journey of obesity, 44(4), 812–822. https://doi-org.proxy.lib.ltu.se/10.1038/s41366-019-0511-0

Brown, V., Ananthapavan, J., Sonntag, D., Tan, E. J., Hayes, A., & Moodie, M. (2019). *The potential for long-term cost-effectiveness of obesity prevention interventions in the early years of life.* Pediatric obesity, 14(8). https://doi-org.proxy.lib.ltu.se/10.1111/ijpo.12517

Canaway, A., Frew, E., Lancashire, E., Pallan, M., Hemming, K., Adab, P., & WAVES trial investigators. (2019). *Economic evaluation of a childhood obesity prevention programme for children: Results from the WAVES cluster randomised controlled trial conducted in schools.* PloS one, 14(7). https://doi-org.proxy.lib.ltu.se/10.1371/journal.pone.0219500

Cradock, A. L., Barrett, J. L., Kenney, E. L., Giles, C. M., Ward, Z. J., Long, M. W., ... & Gortmaker, S. L. (2017). *Using cost-effectiveness analysis to prioritize policy and programmatic approaches to physical activity promotion and obesity prevention in childhood.* Preventive medicine, 95, S17-S27. https://doi-org.proxy.lib.ltu.se/10.1016/j.ypmed.2016.10.017

Döring, N., Mayer, S., Rasmussen, F., & Sonntag, D. (2016). *Economic evaluation of obesity prevention in early childhood: methods, limitations and recommendations.* International journal of environmental research and public health, 13(9). https://doi-org.proxy.lib.ltu.se/10.3390/ijerph13090911

Evers, S., Goossens, M., De Vet, H., Van Tulder, M., & Ament, A. (2005). *Criteria list for assessment of methodological quality of economic evaluations: Consensus on Health Economic Criteria.* International journal of technology assessment in health care, 21(2), 240-245.

Frew, E. (2017). *Aligning health economics methods to fit with the changing world of public health. Applied health economics and health policy*, 15(3), 287-289. https://doi.org/10.1007/s40258-017-0319-9

Gc V.S., Suhrcke, M., Atkin, A. J., van Sluijs, E. M. F., & Turner, D. (2019). *The cost-effectiveness of physical activity interventions in adolescents: model development and illustration using two exemplar interventions.* BMJ Open. https://doi.org/10.1136/bmjopen-2018-027566

Geidl, W., Abu-Omar, K., Weege, M., Messing, S., & Pfeifer, K. (2020). *German recommendations for physical activity and physical activity promotion in adults with noncommunicable diseases.* International Journal of Behavioral Nutrition and Physical Activity, 17(1), 1–13. https://doi.org/10.1186/s12966-020-0919-x

Gold M.R., Siegel J.E., Russell L.B., & Weinstein M.C. (1996). *Cost-Effectiveness in Health and Medicine.* New York: Oxford University Press.

Gray A.M., Clarke P.M., Wolstenholme J.L., & Wordsworth S. (2011). *Applied Methods of Cost-effectiveness Analysis in Health Care.* Oxford: Oxford University Press.

Haby, M. M., Vos, T., Carter, R., Moodie, M., Markwick, A., Magnus, A., ... & Swinburn, B. (2006). *A new approach to assessing the health benefit from obesity interventions in children and adolescents: the assessing cost-effectiveness in obesity project.* International journal of obesity, 30(10), 1463-1475.

John, J., Wolfenstetter, S. B., & Wenig, C. M. (2012). *An economic perspective on childhood obesity: recent findings on cost of illness and cost effectiveness of interventions.* Nutrition (Burbank, Los Angeles County, Calif.), 28(9), 829–839. https://doi-org.proxy.lib.ltu.se/10.1016/j.nut.2011.11.016

Kestilä, L., Mäki-Opas, T., Kunst, A. E., Borodulin, K., Rahkonen, O., & Prättälä, R. (2015). *Childhood adversities and socioeconomic position as predictors of leisure-time physical inactivity in early adulthood.* Journal of physical activity and health, 12(2), 193-199.

Kesztyüs D. and Steinacker JM. (2017). *Health and Economy - Why We Need to Promote Physical Activity in Children. / Gesundheit und Ökonomie - Warum wir körperliche Aktivität bei Kindern fördern sollten.* German Journal of Sports Medicine / Deutsche Zeitschrift Fur Sportmedizin, 68(4), 85–91.

Kohl, H. W., Craig, C. L., Lambert, E. V., Inoue, S., Alkandari, J. R., Leetongin, G., & Kahlmeier, S. (2012). *The pandemic of physical inactivity: global action for public health.* The lancet, 380(9838), 294-305.

Laine, J., Kuvaja-Köllner, V., Pietilä, E., Koivuneva, M., Valtonen, H., & Kankaanpää, E. (2014). *Cost-Effectiveness of Population-Level Physical Activity Interventions: A Systematic Review.* American Journal of Health Promotion, 29(2), 71–80.

Lee, I. M., Shiroma, E. J., Lobelo, F., Puska, P., Blair, S. N., Katzmarzyk, P. T., & Lancet Physical Activity Series Working Group. (2012). *Effect of physical inactivity on major noncommunicable diseases worldwide: an analysis of burden of disease and life expectancy.* The lancet, 380(9838), 219-229.

Lehnert, T., Sonntag, D., Konnopka, A., Riedel-Heller, S., & Koenig, H.-H. (2012). *The long-term cost-effectiveness of obesity prevention interventions: systematic literature review.* Obesity Reviews, 13(6), 537–553. https://doi-org.proxy.lib.ltu.se/10.1111/j.1467-789X.2011.00980.x

Messing, S., Rütten, A., Abu-Omar, K., Ungerer-Röhrich, U., Goodwin, L., Burlacu, I., & Gediga, G. (2019). *How Can Physical Activity Be Promoted Among Children and Adolescents? A Systematic Review of Reviews Across Settings.* Frontiers in public health. https://doi-org.proxy.lib.ltu.se/10.3389/fpubh.2019.00055

Moodie M.F., Sculper M.J., Claxton K., Stoddart L. G. & Torrance W.G. (2015). *Methods for the Economic Evaluation of Health Care Programmes.* (4. ed.). Oxford: Oxford University Press.

Moodie, M. L., Herbert, J. K., de Silva-Sanigorski, A. M., Mavoa, H. M., Keating, C. L., Carter, R. C., ... & Swinburn, B. A. (2013). *The cost-effectiveness of a successful community-based obesity prevention program: The be active eat well program.* Obesity, 21(10), 2072-2080.

Moodie, M., Haby, M. M., Swinburn, B., & Carter, R. (2011). *Assessing cost-effectiveness in obesity: active transport program for primary school children—TravelSMART schools curriculum program.* Journal of physical activity and health, 8(4), 503-515.

Moodie, M., Haby, M., Galvin, L., Swinburn, B., & Carter, R. (2009). *Cost-effectiveness of active transport for primary school children-Walking School Bus program.* International journal of behavioral nutrition and physical activity, 6(1). https://doi-org.proxy.lib.ltu.se/10.1186/1479-5868-6-63

Petrou, S., & Gray, R. (2005). *Methodological challenges posed by economic evaluations of early childhood intervention programmes.* Applied health economics and health policy, 4(3), 175-181. https://doi-org.proxy.lib.ltu.se/10.2165/00148365-200504030-00006

Pringle, A., Cooke, C., Gilson, N., Marsh, K., & McKenna, J. (2010). *Cost-effectiveness of interventions to improve moderate physical activity: a study in nine UK sites.* Health education journal, 69(2), 211-224.

Public Health Agency of Sweden (own translation). (2019). Health Economic Evaluations. Collected 2020-05-02 from https://www.folkhalsomyndigheten.se/folkhalsorapportering-statistik/halsoekonomi-ny/halsoekonomiska-utvarderingar/

Räsänen, P., Roine, E., Sintonen, H., Semberg-Konttinen, V., Ryynänen, O. P., & Roine, R. (2006). *Use of quality-adjusted life years for the estimation of effectiveness of health care: A systematic literature review.* International journal of technology assessment in health care, 22(2), 235-241.

Sefton, T., Byford, S., McDaid, D., & Hills, J. (2002). *Making the most of it: economic evaluation in the social welfare field.* York Publishing Services.

Socialstyrelsen. (2014). *Nationella riktlinjer för hjärtsjukvård.* Retrieved from https://www.socialstyrelsen.se/globalassets/sharepoint-dokument/artikelkatalog/nationella-riktlinjer/2018-6-28-halsoekonomiskt-underlag.pdf

Sutherland, R., Reeves, P., Campbell, E., Lubans, D. R., Morgan, P. J., Nathan, N., ... and Wiggers, J. (2016). *Cost effectiveness of a multi-component school-based physical activity intervention targeting adolescents: the 'Physical Activity 4 Everyone' cluster* *randomized trial*. International journal of behavioral nutrition and physical activity, 13(1).

Svensson, K. (2019). *Hälsoekonomisk utvärdering: Metod och tillämpningar* (1.ed.). Lund: Studentlitteratur

Swedish Agency for Health Technology Assessment and Assessment of Social Services (SBU). (2017a). *Hälsoekonomiska utvärderingar.* Retrieved from https://www.sbu.se/globalassets/ebm/metodbok/sbushandbok_kapitel11.pdf

Swedish Agency for Health Technology Assessment and Assessment of Social Services (SBU). (2017b). *Litteratursökning.* Retrieved from https://www.sbu.se/globalassets/ebm/metodbok/sbushandbok_kapitel04.pdf

Swedish Agency for Health Technology Assessment and Assessment of Social Services (SBU). (2017c). *Kvalitetsgranskning av studier.* Retrieved from https://www.sbu.se/globalassets/ebm/metodbok/sbushandbok_kapitel06.pdf

Wang, H., Li, T., Siahpush, M., Chen, L. W., & Huberty, J. (2017). *Cost-effectiveness of ready for recess to promote physical activity in children.* Journal of School Health, 87(4), 278-285.

World Health Organization. (2011). Global Strategy on Diet, Physical Activity and Health (Information sheet: global recommendations on physical activity for health 5-17 years old). Collected 2020-05-02 from https://www.who.int/dietphysicalactivity/publications/recommendations5_17years/en/

World Health Organization. (2019). Classification (International Classification of Health Interventions, ICHI). Collected 2020-05-20 from https://www.who.int/classifications/ichi/en/

World Health Organization. (2020). Noncommunicable diseases and their risk factors. Collected 2020-05-01 from https://www.who.int/ncds/prevention/physical-activity/inactivity-global-health-problem/en/

Wu, S., Cohen, D., Shi, Y., Pearson, M., & Sturm, R. (2011). *Economic analysis of physical activity interventions*. American journal of preventive medicine, 40(2), 149-158. https://doi-org.proxy.lib.ltu.se/10.1016/j.amepre.2010.10.029

Zanganeh, M., Adab, P., Li, B., & Frew, E. (2019). *A systematic review of methods, study quality, and results of economic evaluation for childhood and adolescent obesity intervention.* International journal of environmental research and public health, 16(3). https://doi.org/10.3390/ijerph16030485