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**The Feasibility of Applying a Systems Approach to
Developing Childhood Obesity Prevention Interventions
in Makkah, Saudi Arabia**



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September 2022

A dissertation submitted to the University of Bristol in accordance with the requirements of the degree of Doctor of Philosophy in the Faculty of Social Sciences and Law

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Abstract

Background: Addressing childhood obesity is challenging due to its complexity. There has been an increasing demand for using a systems approach to tackling complex public health issues such as obesity. A few empirical studies have used this approach. However, all studies were conducted in Western populations. This brings up the issue of whether it is feasible to apply such an approach established in developed nations to culturally diverse, non-Western settings with different political systems.

Aim: This thesis aimed to assess the feasibility of applying a systems approach to developing childhood obesity prevention interventions in Makkah, Saudi Arabia.

Methods: This aim was addressed through five interrelated studies that answered different but complementary research questions. These included a) a systematic review of modifiable risk factors of childhood obesity in Saudi; b) an international scoping review of empirical, comprehensive application of a systems approach to obesity prevention; c) two qualitative studies exploring the readiness of the community for addressing childhood obesity, and decision makers' perspectives regarding the use of systems approach respectively, and d) a pilot Group Model Building workshop to test the feasibility and gain practical insights.

Results: Existing literature on modifiable risk factors in Saudi is predominated by individual-level factors. Several areas must be improved before Saudis can successfully apply a systems approach to developing childhood obesity prevention interventions. Weaknesses include the current limited evidence-based, ineffective leadership, lack of collaboration and partnerships, and severely limited capacities and capabilities of local authorities and the workforce. Some positive (but limited) evidence on the effectiveness of a systems approach is available from high-income Western countries. Research from non-Western, low- and middle-income countries is lacking.

Conclusion: This PhD highlighted the importance of assessing the feasibility of applying a systems approach to developing obesity prevention interventions in non-western populations, particularly those with a highly centralised political system. The next step for Saudis should be targeting those identified weak areas to improve the feasibility of applying a systems approach to childhood obesity prevention.

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Author's Declaration

I declare that the work in this dissertation was carried out in accordance with the requirements of the University's Regulations and Code of Practice for Research Degree Programmes and that it has not been submitted for any other academic award. Except where indicated by specific reference in the text, the work is the candidate's own work. Work done in collaboration with, or with the assistance of, others, is indicated as such. Any views expressed in the dissertation are those of the author.

SIGNED:..... DATE: 16/09/2022

Publications and Conferences

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Abbreviations

CBSA	Community-based systems approach
SA	Saudi Arabia
GDP	Gross Domestic Product
NCDs	Non-communicable chronic diseases
GMB	Group Model Building
SPS-REC	School for Policy Studies Research Ethics Committee
DMs	Decision-makers
SEM	Socioecological Model
CRM	Community Readiness Model
LAs	Local authorities
BMI	Body Mass Index
WHO	World Health Organisation
US	United States
UK	United Kingdom
IOTF	International Obesity Taskforce
CDC	Centres for Disease Control and Prevention
RCT	Randomised controlled trial
QOL	Quality of life
AUS	Australia
PA	Physical activity
MPA	Moderate-intensity PA
VPA	Vigorous-intensity PA
SSB	Sugar-sweetened beverages
PE	Physical education
SES	Socio-economic status
TV	Television
MLMC	Multilevel and multicomponent
cRCT	Cluster randomised controlled trial
AUS	Australia
CBI	Community-based interventions
CBSI	Community-based systems interventions
WHOSTOP	Whole of Systems Trial of Prevention Strategies for Childhood Obesity
CLD	Causal loop diagram
MOH	Ministry of Health
MECs	Middle Eastern countries
ST	Screen time
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
AXIS	Appraisal tool for Cross-Sectional Studies
WHO-NHEC	World Health Organisation- National Health and Education Consortium
WSA	Whole system approach
NICE	National Institute for Health and Care Excellence
SW RCT	Stepped-wedged randomised control trial design
SCAS-EPPI	Standard Critical Appraisal Skills Programme and EPPI-Centre
RESPOND	Reflexive Evidence and Systems interventions to Prevent Obesity and Non-communicable Disease
LIKE	Lifestyle Innovations based youth's Knowledge and Experience
STICKE	Systems Thinking for Community Knowledge Exchange
TA	Thematic analysis
NPOs	Non-profit health organisations
HTV	Healthy Together Victoria
MOE	Ministry of Education

Chapter 1: Introduction

1.1 Thesis rationale

Preventing and controlling public health issues such as childhood obesity is challenging because of their complexity. Past approaches were limited by focusing only on the linear relationship (cause-effect) and individual behaviours. Recently, public health research and practice have increasingly acknowledged the importance of using systems-based approaches to address the complexity of childhood obesity.^{1,2}

A few empirical studies have tried to apply a community-based systems approach (CBSA) to public health interventions to replace traditional approaches that use simple and/or multi-setting interventions.^{3,4} However, all those studies were centred on Western populations. This brings up the issue of whether it is possible to apply the CBSA established in developed nations to culturally diverse non-Western settings with different political systems. Applying the CBSA to obesity prevention requires a shared goal and collective effort across all levels.⁵ These would be challenging in many non-Western countries, particularly those with a highly centralised governance system.

Research gaps regarding the feasibility of applying the CBSA to tackling complex public health issues in non-Western populations must be acknowledged and addressed. The feasibility of using this approach within non-Western nations needs to be understood, along with identifying the areas requiring improvement. This is fundamental for scholars and policymakers in non-Western settings to attempt or adapt this new approach to improving public health.

Since the term "systems approach" is somewhat broad, I focused particularly on CBSA in this thesis. Therefore, where the "systems approach" is mentioned throughout the thesis, it mainly means the CBSA.

1.2 Background of Saudi Arabia

The profile of Saudi Arabia (SA) is shown in Table 1-1. It is noteworthy that despite its evident affluence derived from decades of oil exports to several countries, SA is still regarded as a 'Third World' country. The country resides in the central part of the Arabian Peninsula and at the intersection of the three continents (Africa, Europe and Asia), making it a significant centre of commerce and trade. It has a surface area of around 2 million km², making it the largest country in the Arabian Gulf and the fifth-biggest country in Asia. By the end of 2021, the Gross Domestic Product (GDP) of SA was around \$1.5 trillion.⁶ In 2020, the population of SA was nearly 35 million; however, only 65 % were Saudi nationals. Around 25 % (8.5 million) of the population is under 14 years. Ages 15 to 64 account for more than two-thirds of the country's population (72%). Only 3 % of the population is ages 65 and over.⁷

Table 1-1: Saudi Arabia Profiles

Population, total (millions)	34.81
Population growth (annual %)	1.6
Surface area (sq. km) (thousands)	2,149.70
Population density (people per sq. km of land area)	16.2
Life expectancy at birth, total (years)	75
Fertility rate, total (births per woman)	2.3
Adolescent fertility rate (births per 1,000 women ages 15-19)	7
Mortality rate, under 5 (per 1,000 live births)	7
Primary completion rate, total (% of relevant age group)	99
School enrolment, primary (% gross)	100.2
School enrolment, secondary (% gross)	113
GDP (current US\$) (billions)	700.12
GDP growth (annual %)	-4.1
Inflation, GDP deflator (annual %)	-7.9
Tax revenue (% of GDP)	7.4
Individuals using the Internet (% of the population)	97.9

Source: World Bank 2020⁷

There are 13 provinces in SA, divided into 136 governates (Figure 1-1). Riyadh is the capital city of SA and the country's largest metropolis. The most significant city in SA is named “Makkah” (the location of the work of this thesis), situated in the country's western part.⁸ SA was not economically important until the 1930s, when enormous amounts of oil were discovered. About a fifth of the world's confirmed oil reserves is in SA. As a result of the rapid transformation, earnings climbed by over 75% between 2004 and 2013.⁹ In 2020, the urban population of SA was estimated to be 85% of the total population. The dramatic increase in urbanisation has hugely influenced many areas of Saudis' everyday life, including sedentary, dietary, and physical lifestyles. In SA, Non-communicable chronic diseases (NCDs) and conditions such as obesity are approaching alarming levels, as previously reported in developed nations.¹⁰ More details about the prevalence, risk factors and prevention of childhood obesity in SA are reported in Chapter 2.

Figure 0-1: Saudi Arabia's Map



1.3 COVID-19 impacts on the thesis

It is worth noting that the significant impact of COVID-19 was on the title of this PhD thesis and research design. This thesis was initially designed to use the CBSA to develop childhood obesity prevention interventions in SA. The pre-COVID-19 research plan was to conduct four Group Model Building (GMB) workshops. Workshops one and two were planned to be held with decision-makers, workshop three was designed to involve the wider community, and the final workshop was intended to recruit parents and children. Unfortunately, while preparing to apply for ethical approval and starting fieldwork, the global COVID-19 pandemic occurred. As a result, the School for Policy Studies Research Ethics Committee (SPS-REC) has suspended all ethics applications and fieldwork, advising to use of online methods to collect data. Moreover, the Saudi government imposed a travel ban to and from the country. Under this circumstance, a discussion with supervisors led to the decision that the research aim, and data collection methods should be modified.

During the data collection process, it was expected that using a third party (gatekeeper) and the availability of decision-makers (DMs) might be limited due to the COVID-19 crisis. However, a mitigation plan was developed in case of such difficulty in the recruitment process, which entailed the recruitment of deputy DMs at the same authority or organisation.

1.4 Thesis overview

Chapter one presents the research arena of this thesis related to obesity among children and its prevention, with a specific emphasis on obesity among Saudi children. It reports the findings of two reviews and qualitative studies that explored the feasibility of taking CBSA to develop childhood obesity prevention within the Saudi community. In turn, this

provides evidence-based insights to inform future work in this setting. Each chapter focuses on a specific aspect and offers a comprehensive background, research objectives, methods, results, and discussion.

Chapter 2

This chapter reviews both the Saudi and international literature on the aetiology, prevalence and approaches used to address obesity among children. Several critical gaps in research are identified and discussed, providing a foundation for the ultimate aim of this study. This chapter ends by specifying the aim and objectives of this thesis.

Chapter 3

This chapter presents a systematic review of modifiable risk factors associated with obesity among Saudi children aged 2 to 18 years. In addition, the findings of this review were mapped onto the Socioecological Model (SEM) to determine which levels of childhood overweight/obesity determinants have been examined extensively and which still need further research.

Chapter 4

This chapter presents a scoping review of empirical evidence on the comprehensive application of the systems approach to obesity prevention, including the effectiveness and common features of this approach. In addition, documented barriers and facilitators to applying a comprehensive systems approach in practice are presented.

Chapter 5

This chapter reports a qualitative study using the Community Readiness Model (CRM) to assess the stage of readiness of the Makkah community to address childhood obesity.

Following a scoring process, the targeted community's readiness stage is presented. A qualitative analysis of interviews is also presented to help interpret the readiness levels. Furthermore, a discussion of how the CRM dimensions can contribute to a better understanding of using the CBSA within the targeted community is also presented.

Chapter 6

This chapter reports a qualitative study of the views of 18 DMs drawn from local authorities (LAs) and relevant organisations on using the CBSA for childhood obesity prevention in Makkah. Following a thematic analysis, enhanced and hindered factors to applying the CBSA are presented and discussed.

Chapter 7

This chapter reports on a small-scale, pilot workshop conducted virtually. The challenges and success of recruiting representatives from LAs and relevant organisations are presented. In addition, issues related to the workshop process (key activities) and the researcher's experience and observations are provided.

Chapter 8

This chapter draws all findings from previous chapters into a discussion. The implications of this PhD study are discussed. Contributions, limitations and strengths of the thesis and an overall conclusion are provided in this chapter.

Chapter 2: Literature review

2.1 Chapter overview

Obesity in childhood is now considered a global health burden. The problem of obesity in childhood concerning its definition, prevalence, consequences, causes, economic burden and prevention are discussed in this chapter. Additionally, the issues of obesity among Saudi children that are the focus of this PhD research are also articulated in this chapter.

2.2 Defining obesity and Body Mass Index

Obesity describes the excess or abnormal accumulation of fat by which an individual's health may be impaired.¹¹ This simple definition is of considerable contention, particularly when measuring obesity. In practice, measuring body fat directly is challenging, whether in population studies or clinical applications, because there are no accurate, practical and economical means to measure body fat directly.¹²⁻¹⁵ This explains why body weight rather than body fat is used in most studies about obesity. In epidemiological studies, weight measurement is used to estimate body fat.¹³

Body mass index (BMI) is a popular indirect method used for assessing weight status. It is a mean in which a person's BMI is calculated by dividing their weight in kilogrammes (kg) by their height in metres squared (m^2).^{16,17} The World Health Organisation (WHO) developed an international classification in which the cut-off point for overweight is defined as $25\text{kg}/m^2$ to $29.9\text{kg}/m^2$, while the cut-off point for obesity is between $30\text{kg}/m^2$ and $39.9\text{kg}/m^2$, more than $40\text{kg}/m^2$ is defined as morbidity obesity.¹⁶ The reason for widely using this method as an indirect measure for body fat and then determining obesity

is that it is a simple process and inexpensive compared to other measures of obesity. Therefore, it can be undertaken at a population level.

Despite the widespread use and advantages of BMI, it is essential to note that it measures body weight rather than body fat. Consequently, using BMI for determining obesity has several limitations. Firstly, the association between BMI and body fat percentage varies between ethnic groups.¹⁸ For example, the proportion of body fat in South Asians is often greater than that of Whites at a given BMI.¹⁹ This means South Asian populations are at increased risk of diabetes or mortality at lower BMIs.²⁰

Secondly, BMI cannot determine the distinction between fat mass and fat-free mass because it assesses body weight instead of body fat.²¹ This limitation raises a concern that some individuals may be incorrectly categorised as being at reduced risk of the health effects of obesity at a greater fat percentage or at higher risk when their fat percentage is lower. This concern was highlighted in a systematic review and meta-analysis of 37 worldwide studies assessing the diagnostic performance of BMI as a marker for adiposity in children aged 0-18 years.²² They found that the specificity of BMI is high at 93%, but the sensitivity of BMI is low at 73%, and more than a quarter of children with excess body fat percentage were not identified using BMI. It is particularly important to differentiate between fat and lean mass, as they affect health outcomes, including mortality. The excess lean mass has been deemed advantageous to health,²³ whereas excess fat mass is linked to various health risks, including cardiovascular disease.²⁴

Other methods, such as bioelectrical impedance, waist circumference and skinfold thickness, are used to estimate body fat in epidemiological studies to define adiposity.¹⁵

2.3 Childhood obesity and Body Mass Index

Measuring obesity in children is more complicated due to their continuous growth and differences between genders in growth patterns. Within epidemiological studies, the most common means for measuring obesity in children over two years is BMI. However, the cut-off points of BMI in adults are not linked to age and do not discriminate between genders. As a result, a BMI reference chart based on age and sex is used to define childhood obesity and overweight.²⁵

Two types of reference standards are now available: international and national. In the United States (US), BMI for age reference was derived from weight and height data collected between 1963 and 1980 from girls and boys ages 2 to 20 years.²⁶ Similar national reference standards also exist in Sweden,²⁷ China,²⁸ Italy,²⁹ France,³⁰ and the United Kingdom (UK).¹⁷ However, using different standards to define childhood obesity and overweight makes the international comparisons challenging due to inconsistency in reporting childhood obesity and overweight.³¹ To counter this issue, an international sex-specific BMI cut-off points for childhood obesity and overweight aged 2 to 18 years was developed in 2000.³² This quasi-centile curve was extrapolated from the adult cut-off points of 25 to 30 kg/m² using data from different countries, including the USA, the UK, Brazil, Hong Kong, Netherlands and Singapore. In addition, in 2007, the WHO developed a reference for adolescents and school-aged children.³³ Table 2-1 summarises the different childhood obesity international reference standards, including WHO, Centres for Disease Control and Prevention (CDC), and International Obesity Taskforce (IOTF).

Table 2-1: Different childhood obesity international reference standards

	The growth references/standards (Children)		
	WHO³³	CDC³⁴	IOTF³⁵
Data set	US	US	Six countries (UK, US, Singapore, Brazil, Hong Kong, Netherlands)
Sample	22,917	4,697	192,727
Ages	5-19y	2-19y	2-18y
Classification	Overweight: >1 to ≤ 2 SD Obese: >2 SD	Overweight: ≥ 85 th to <95th Obese: ≥ 95 th	Overweight: BMI = 25 Obese: BMI = 30

Debate is still ongoing on which BMI-based classification system (WHO, CDC, IOTF) is used to determine the prevalence of childhood obesity and overweight. As each of these systems is based on different populations and methodologies for determining the BMI cut-off points, it is expected to underestimate the prevalence of obesity and overweight in children. A recent Malaysian study assessing the prevalence of obesity, overweight and underweight among children aged between 6 and 18 years found that the estimated prevalence of overweight and obesity were higher when using the WHO reference, and the prevalence of obesity was approximately 4% lower when using the IOTF reference.³⁶

2.4 Childhood obesity and other measures

Other non-weight-based indirect measures of obesity have been used in children and adults, such as skinfold thickness, waist circumference and bioelectrical impedance analysis.

Skinfold thickness is sometimes used to assess body fat percentage by measuring skinfold thickness at specific locations such as subscapular, biceps and triceps. It is a useful technique for determining body fat distribution in individuals. However, the validity of utilising skinfolds to estimate body fatness is impacted by the calliper used and the measuring methodologies used, with inter-and intra-observer variances being major

problems.^{37,38} Furthermore, equations based on these measures have been criticised for a long time, and it was suggested that established equations generally underestimate body fat percentage.^{39,40}

Waist circumference, typically achieved by measuring halfway between the rib cage and iliac crest, correlates highly with central obesity. As a result, waist circumference is preferable to BMI because it shows where fat is distributed. When waist circumference is evaluated using computed tomography in children, a strong correlation exists between both types of fat.⁴¹ However, waist circumference is inadvisable as a regular measurement. It might be used to provide extra information about the likelihood of acquiring other chronic health conditions.⁴²

2.5 Prevalence of childhood obesity and overweight

2.5.1 The global prevalence of childhood obesity

Between 1975 and 2016, the worldwide population of obese children (5-19 years) increased tenfold. By 2025, it is anticipated that over 265 million children (5-17 years) might be overweight or obese worldwide.^{11,43} The worldwide obesity rate among school-aged children has climbed from 0.7% to nearly 5.5% in girls and from 0.9% to around 7.9% in boys over the four decades, whereas the global obesity rate for underweight children has dropped.⁴⁴ These boys-girls differences in obesity prevalence may be influenced partly by sociocultural factors. For example, meat and high-calorie meals tend to be more popular among boys than girls.^{45,46} Moreover, body image and body size views are influenced by culture. For example, various African nations have seen overweight females as attractive.^{47,48} Given the variety of methods used and the differences in obesity definition, there might be an underestimation of obesity prevalence among children.

Childhood obesity was traditionally associated with developed nations; however, growing data indicates that the epidemic has also spread to developing countries and become a pandemic. In 2016, the Pacific Islands, such as Palau, Nauru, and the Cook Islands, had the highest prevalence of childhood obesity among school-aged children (5-19 years), with roughly one-third for girls and boys. In contrast, these islands are considered minor states in terms of population. Countries such as the US, China, and parts of the Middle East have a greater population, reflecting the accurate picture of childhood obesity prevalence where more than 20% of children aged 5-19 years are obese.⁴⁴ Rapid socio-economic growth in developing nations, as seen in Chile and Brazil, is mainly responsible for the rapid increase in the prevalence of childhood obesity.¹⁵ However, comparing the prevalence of obesity among children in developed and developing nations indicates that the prevalence of obesity among children from middle and higher socio-economic classes is lower in developed countries than it is in developing countries.⁴⁹

2.5.2 The Saudi prevalence of childhood obesity

The WHO data revealed that the prevalence of childhood obesity has increased from 13% in 2009 to nearly 17% in 2016 among Saudi school-aged children. Girls had a greater increase (from 11.7 % to 14.4 %) than boys (from 18.1% to 19.8%) in the same period.⁵⁰ In 2030, obesity is expected to affect more than 1.8 million Saudi children aged 5 to 19 years.⁵¹ This trend is an alarming development for Saudi's public health, considering that around a quarter of the Saudi population is under 14 years of age.⁵²

Overweight and obesity among children are seldom studied nationally in SA, despite the large number of research conducted locally that reveal an increasing trend in obesity among SA's youth. In 2002, a national survey of roughly 12,700 children aged 1 to 18 years using IOTF criteria found that obesity prevalence was 6.8% for boys and 6.6% for

girls.⁵³ In 2010, a national survey of nearly 19,000 school-aged children reported that the prevalence of overweight and obesity among girls was 22.4%, whereas it was about 23.8% for boys (Saudi growth chart was used).⁵⁴ However, the latest national survey in 2019 of roughly 445,000 children aged 4-14 years shows lower rates than the previous national surveys. The 2019 survey using the 2016 Saudi reference found that the overweight prevalence was around 6.5 %, whereas the obesity prevalence was about 4%.⁵⁵ These differences in estimating the prevalence of obesity and overweight among Saudi children may be attributed to the type of growth charts used. It was affirmed that utilising growth charts from countries other than SA overestimates the prevalence of obesity and overweight among Saudi children.⁵⁶

2.6 Consequences of childhood obesity

Obesity is at the top of the WHO's priority list for public health. This is due to the rapidly growing and preventive nature of the pandemic as well as its well-established links with major NCDs, numerous cancers, and heavy socio-economic burdens.

2.6.1 Health consequences

Epidemiological research indicates that overweight and obesity in children are associated with cardiovascular risk factors. A systematic review and meta-analysis of 63 studies (one case-control study, one cohort study, 19 randomised controlled trials (RCT) and 42 cross-sectional studies), including 49,000 children aged 5 to 15 years, determined the association between BMI and risk of cardiovascular disease.⁵⁷ According to the review, having a BMI over the normal range significantly affects risk characteristics for cardiovascular illnesses in children.⁵⁷ Furthermore, a US study examined cardiovascular risk factors among 9,167 obese and non-obese children aged 5 to 17 years. Obesity was

defined as having a BMI more than or equivalent to the 95th percentile. It was shown that around over half of obese children had at least one risk factor for heart disease.⁵⁸

The relationship between childhood asthma and obesity has been widely documented. A meta-analysis of prospective epidemiologic studies on children revealed that overweight children had a 20% increased risk of developing asthma and that children who are obese have a twofold increased risk, with a dose-response association between incident asthma and body weight.⁵⁹ Moreover, a US retrospective study included almost half a million children to compare the incidence of asthma among obese and/or overweight children to children of normal weight aged 2 to 17 years.⁶⁰ Children who were overweight ([RR]: 1.1; 95% (CI: 1.1-1.2) or obese (RR: 1.2; 95% CI: 1.1-1.3) had a higher adjusted risk of developing incident asthma. Without overweight and obesity, 10% of all asthma cases may be averted.⁶⁰

Adult obesity is well-established as a risk factor for premature mortality and various illnesses. Thus, it is critical to understand the link between obesity in childhood and adulthood. If childhood obesity is a significant predictor of adulthood obesity, the increased prevalence of childhood obesity may have far-reaching health effects for adults in the future. This has resulted in much research on the progression of obesity throughout adulthood. A systematic review and meta-analysis of 73 studies was conducted to determine the ability of basic measurements to predict obesity persistence into adulthood.⁶¹ Twenty-three out of the 73 studies for tracking obesity into adulthood were longitudinal cohort studies with a follow-up between 6 and 42 years. There was a significant positive association between having a high BMI as a child and being obese as an adult. The review also found that having a high BMI as a child is associated with diabetes, coronary heart disease, and cancers in adulthood.⁶¹

Throughout the last decade, new attention has been paid to the association between weight status and sleep in children. Sleep disorders and obstructive sleep apnoea are associated with childhood obesity.^{62,63} In children with severe obesity and obstructive sleep apnoea, clinically substantial impacts on learning and memory performance are alarming.⁶⁴ Obstructive sleep apnoea may increase the risk of cardiovascular disease in obese children.⁶⁵

Being overweight or obese has far-reaching consequences on a child's mental health, garnered more interest in recent years. A systematic review and meta-analysis of 28 studies examined the association between childhood obesity or overweight and psychological issues. The review found a significant positive association between low self-esteem and obesity or overweight in children.⁶⁶ While prior research has shown a relationship between obesity in children and a higher risk of developing depression, the findings have been inconsistent. The same review found no relationship between childhood obesity or overweight and anxiety, depression, or body dissatisfaction.⁶⁶ However, another review of 22 observational studies, including children under 18 years, identified a significant association between depression and obesity only in girls.⁶⁷

Treatment of childhood obesity influences the child's psychological well-being. A systematic review and meta-analysis included 64 studies (one retrospective review, five non-RCTs, 23 RCTs, and 36 pre-post designs) examining the impact of obesity treatment on children's psychological health.⁶⁸ They found that both short- and long-term improvements in self-esteem and body image can be achieved with obesity treatment.

The association between obesity in children and quality of life (QOL) is well-established in the literature. A review of 34 studies to assess the relationship between overweight or obesity in children under 18 years and QOL reported that 31 out of 34 studies reported a

reduced QOL among obese children.⁶⁹ Furthermore, a prospective study on 120 severely obese children aged 8 to 19 years found that one-year lifestyle interventions significantly improved weight-related QoL.⁷⁰

2.6.2 Economic costs

Along with the major health and psychological consequences of childhood obesity, there are also significant financial burdens on society. Many developed and developing nations have studied the economic costs of obesity. However, a systematic review of 32 studies reported that studies employ diverse methodologies and define obesity-related expenses differently, making it difficult to compare them.⁷¹ Obesity prevalence reduction forecasts need to take these disparities into account.

A recent cost of illness study included 59 articles from eight countries (Thailand, Spain, South Africa, SA, Mexico, India, Brazil, and Australia (AUS)) sought to estimate the economic costs of overweight and obesity in those countries in 2019 and 2060.⁷² The study reported that direct (e.g. costs of treatments, examinations and medications)⁷³ and indirect (e.g. absenteeism and presenteeism)³² obesity expenses in 2019 are on average 1.8 % of GDP across the included countries, ranging from 0.8 % of the Indian GDP to nearly 2.5 % of the Saudi GDP. It is predicted that the economic impact of obesity would average 3.6% of GDP across the included countries in four decades.⁷² Globally, obesity costs the world economy an estimated over US\$2 trillion each year, or nearly 2.8% of the global GDP.^{73,74}

In SA, the economic cost of obesity and overweight was expected to reach over US\$ 19 billion, which amounts to nearly 2.5% of the Saudi GDP. Direct expenses accounted for 26.2 % of costs, while indirect costs accounted for 73.8 %. By 2060, the economic

impacts are expected to reach over US\$75 billion, equating to 4.2 % of the Saudi GDP, or a fourfold rise in overall expenses.⁷⁵

2.7 Aetiology of childhood obesity

2.7.1 An international perspective

In general, obesity is a result of the imbalance between calorie intake and calorie expenditure, the number of calories consumed and expended, resulting in an overproduction of body fat.¹¹ However, this explanation is too simple, which hides the complex causes that influence the development of obesity. The following subsections provide an overview of factors contributing to childhood obesity.

2.7.1.1 Biological influences

Family, adoption and twin studies have been critical in advancing our knowledge of how genetic variables influence the risk of obesity. A family study including over 12,000 men and women who were followed up over time reported that Parental obesity correlates strongly with BMI. Children with non-obese parents are less likely to develop obesity than those born to obese parents.^{76,77} It is challenging to determine whether the correlation comes from genes or environmental factors in family studies. A recent study of almost 87,500 twin pairs from 45 cohort studies found that genetic variables significantly affect BMI variance.⁷⁸ By pooling available cohort data from twin and family studies, many meta-analyses showed recurring genetic and environmental changes in BMI from infancy through adulthood.⁷⁸⁻⁸⁰ Heritability estimates tend to grow with the age of children in the family and twin studies but begin to decline around 18 years old.⁸⁰ Heritability estimates for research involving children aged 5 to 18 years vary between 0.58 and 0.89.⁸⁰ However, only 5% of all cases of childhood obesity are thought to be genetic in nature. Thus, the

fast development of obesity throughout the globe is still impossible to explain only by genetic variables.

2.7.1.2 Behavioural influences

Obesity among children is increasing globally for various reasons that go beyond just biological influences. Behavioural influences such as sedentary behaviour, physical activity (PA), diet and sleep have significantly contributed to escalating childhood obesity rates.

2.7.1.2.1 Sedentary behaviour

Numerous studies have reported an association between sedentary activities and childhood obesity. A systematic review of 29 systematic reviews and meta-analysis was carried out to determine the association between sedentary behaviours and obesity in children from birth to 18 years old.⁸¹ The review indicated that sedentary behaviour was associated with excessive weight. The association was type-dependent, and screen time seems more likely to be associated with obesity than total sedentary time. These findings were supported further by a systematic review and meta-analysis of 37 moderate to high-quality studies, which found that children under the age of 18 years with screen time of more than two hours/day had an increased risk of becoming overweight or obese (OR = 1.67; 95% CI [1.48, 1.88]).⁸²

Additionally, the quality of food consumed while watching TV and the amount of unhealthy food that children are exposed to might influence their weight. It has been shown that screen time increases the number of calories consumed.⁸³⁻⁸⁵ Advertising for foods high in salt, sugar and fat is becoming more prevalent when watching television, encouraging children to spend on these goods.^{85,86} A systematic review and meta-analysis of 22 studies examining the relationship between exposure to unhealthy food and food

intake reported a direct link between food advertising and children's food choices, purchases, and consumption.⁸⁷ Children's food consumption is also influenced by advertising which also can make children harass parents into purchasing unhealthy.⁸⁸⁻⁹⁰

2.7.1.2.2 Physical activity

Longitudinal association (follow-up ranging from 2 to 8 years) of total body fat and the objective measurement of PA using accelerometers found a negative relationship between the level of PA and future adiposity in children.⁹¹⁻⁹⁴ A review of 14 longitudinal studies evaluating the association between objectively measured PA and body composition in children aged 6 to 15 years reported that a reduction in adiposity was associated with moderate to vigorous PA (MVPA).⁹⁵ This finding was supported by a recent review of 199 observational studies that found MVPA was negatively associated with obesity among children aged 5 to 19 years (OR=0.7) based on 84 studies included in the review.⁹⁶

2.7.1.2.3 Diet

A systematic review of 40 prospective cohort studies assessing the association of obesity among children aged 10 – 18 years with biological, contextual and behavioural variables found conflicting evidence on the association between dietary intake and obesity among the target population.⁹⁷ This finding is supported by another systematic review of 21 longitudinal studies that reported inconsistent evidence of the association between body fat and diet in children aged 10 to 19 years.⁹⁸ However, a systematic review and meta-analysis of 13 reviews exploring the association between sugar-sweetened beverages (SSB) intake and obesity among children under 19 years reported that most of the included reviews reported a direct association between childhood obesity and SSB consumption.⁹⁹ Moreover, a recent review of 199 observational studies of children aged 5 to 19 years reported that the risk of childhood obesity might be reduced by 34% when

eating breakfast every day (OR= 0.66).⁹⁶ Contradictory findings of previous reviews may be due to discrepancies in the research design of included studies, eligibility criteria, and data analysis methods.

2.7.1.2.4 Sleep

Childhood obesity and its association with sleep have been widely examined. Five systematic reviews conducted between 2008 and 2016 (including two meta-analyses) reported a clear association between short sleep and a high risk of obesity among children.¹⁰⁰⁻¹⁰⁴ However, these reviews have been criticised as some of the included studies used subjective measurement of sleep duration, which might have a high bias risk. These reviews were also supported by a systematic review of 33 RCT and observational studies that objectively assessed sleep duration and reported a strong negative association between sleep duration and obesity among children under 19 years.⁶²

2.7.1.3 Environmental influences

Obesity among children is increasing globally for various reasons that go beyond just biological or behavioural influences. Increasingly, environmental factors such as family, neighbourhood, school and socioeconomic factors have been widely accepted as important contributors to escalating childhood obesity rates globally.

2.7.1.3.1 Family factors

Parents may influence their children's eating habits in a significant way. Firstly, parental role modelling has positively impacted children's dietary patterns,¹⁰⁵ screen time,¹⁰⁶ active play,¹⁰⁷ and PA.¹⁰⁸ However, some studies reported that mothers and fathers as role models might affect children's PA differently.^{106,109} For example, a study involved 45 dads and 45 moms and their children ($N=45$, mean age 9.9 years) in examining correlations of activity between parent and child using an accelerometer.¹⁰⁹ The study

found a positive association between moms' PA and their daughters and between dads' PA and their sons.

Parenting style (e.g., authoritative, authoritarian, and permissive) and its association with childhood obesity have received considerable attention. Prospective and cross-sectional evidence has demonstrated the association of parenting style with other psychological outcomes such as depression and stress.^{110,111} Consequently, parenting style might play an important role in developing healthy eating and exercise habits for the long term.¹¹² Many reviews that examined the association between childhood obesity and parenting styles demonstrated the association of children's BMI with an authoritative parenting style.¹¹³⁻¹¹⁶ However, these reviews were based mostly on cross-sectional evidence. One of the numerous shortcomings of cross-sectional data is the inability to determine temporality. Findings of previous reviews were supported by a systematic review of only 11 prospective cohort studies (follow-up ranging from 1 to 11 years) that reported the negative association of the authoritative style of parenting with lower BMI.¹¹²

Home environment domains (e.g., media, food and PA) and their role in shaping behavioural outcomes in children have been extensively examined. A recent systematic review of 62 studies (51 cross-sectional and 11 prospective studies) was conducted to examine the associations of the three domains of home environment (media, food and PA) and adiposity in children under 12 years.¹¹⁷ The review reported that consistent associations were found between the physical aspects of a child's media environment at home, such as availability and access to electronic devices, specifically in the child's room, associated with a higher risk of obesity among children. However, the review found inconsistent findings regarding the association between home PA or food environments with obesity among children.

2.7.1.3.2 Neighbourhood factors

Several reviews have assessed the association of neighbourhood environments with childhood obesity, including neighbourhood food environment¹¹⁸⁻¹²⁵ and built neighbourhood environments.¹²⁶⁻¹³² These prior reviews on the impact of the neighbourhood food environment on children's weight gain found null or mixed findings.^{118,120-123,125} In contrast, the neighbourhood-built environment seemed to have a more substantial relation to childhood obesity.¹²⁷⁻¹³¹ However, previous reviews relied primarily on cross-sectional studies, which do not permit causal inference. A recent systematic review of 39 longitudinal studies (follow-up ranging between 8 months and 20 years) examining the association of neighbourhood environment with children's weight or obesity reported that for the domain of food environment, girls only showed strong evidence of negative effects for junk food outlets.¹³³ For the built environment domain, the review reported that recreational areas, greenery, and parks might benefit children's weight. The review found that low perception of safety and increased crimes might contribute to increasing children's weight in social neighbourhood environment.¹³³

2.7.1.3.3 School environment

A number of cross-sectional studies have shown that childhood obesity is associated with school environment factors. It has been found that involving health professionals, exercising prior to class, encouraging walking or bicycling from/to schools, and the availability of PA-related policies are negatively associated with children's BMI.¹³⁴ Moreover, obesity in children was positively associated with having fully qualified teachers and fewer physical education (PE), whereas negatively associated with PE participation.¹³⁵ In addition, childhood obesity risk is reduced in schools with a PA-friendly environment.¹³⁶ Obesity and/or dietary habits in children are associated with the type of food offered within schools and the presence of vending machines/cafeterias

within schools.¹³⁷⁻¹³⁹ A longitudinal UK study of nearly 1,390 students from different schools concluded that school environments that promote healthy eating and PA might help reduce childhood obesity.¹⁴⁰ However, a systematic review and meta-analysis of 20 studies (4 longitudinal and 16 cross-sectional studies) examining the association of school environments with excessive weight in children aged 10 to 19 years reported that the existence of food programmes or policies within schools was not associated with childhood obesity.¹⁴¹

Recently, great attention has been paid to the association of childhood obesity with the environment surrounding schools. For example, several reviews demonstrated the association of childhood obesity with retail food,^{142,143} fast food restaurants,¹⁴⁴ and hot food takeaways,¹⁴⁵ surrounding schools. However, these reviews point out the need for longitudinal studies and studies looking at the underlying processes of how each subgroup is affected by the food environments around their school.

2.7.1.3.4 Socio-economic factors

Childhood obesity and socioeconomic status (SES) have a complicated association that varies with the country's degree of development.¹⁴⁶ Generally, obesity and SES are associated negatively in high-income countries,^{147,148} while the relationship reverses in low to mid-income countries.¹⁴⁹ Interestingly, for middle-income nations undergoing a dietary transition, a systematic review discovered an inverse association.¹⁵⁰

Turning to SES measures, parental education status, the first most widely used indicator, is more often observed to be inversely correlated with obesity in children than parental income, the second most widely used indicator.^{149,151-154} A longitudinal study of nearly 2,875 children in Western Denmark examined how SES during early (< 8 years) and late childhood (9 to 14 years) was related to obesity/overweight at ages 15, 18 and 21 years.¹⁵⁵

It was reported that at the ages of 18 and 21 years, girls whose parents had a lower educational level during early childhood were more likely to be overweight or obese, while boys whose fathers were less well-educated during early childhood had a 2.4 times higher risk of obesity by the time they were 21 years old. Furthermore, in girls at the age of 18 and both genders at the age of 21 years, a lower level of parental education during later childhood increased the risk of obesity three times.

2.7.1.3.5 Political and policy influences

Several studies have investigated the influence of political features on health outcomes at a country level.¹⁵⁶⁻¹⁵⁹ However, these studies did not provide insights on how political characteristics may affect BMI outcomes. Using data from 1990 to 2007 for 47 developing countries, an investigation of the influence of political factors on BMI distribution was conducted. It was found that political traits have a role in determining BMI, even after adjusting for covariates. Particularly, democratic systems are more likely to decrease underweight but raise obesity or overweight, while successful political competition has a dual advantage of decreasing both obesity and underweight.¹⁶⁰

Efforts by governments to deal with growing obesity rates have been hindered by politicians' distraction on single policies such as taxation on sugar-sweetened drinks and the lack of a level playing field that regulations within the industry can create.⁷⁴ Moreover, a review of England's policies and strategies to reduce obesity concluded that reasons for not reducing the obesity prevalence include the development of unworkable policies, rare evaluation of prior government strategies, the use of fewer interventionist policies and the placement of high demands on the individual body.¹⁶¹

2.7.2 The Saudi's perspective

Generally, lifestyle factors may contribute to SA's growing childhood obesity and overweight rates. However, there is a lack of national data on children's PA, dietary intake, sedentary activities, sleep and SES factors. Moreover, studies about childhood obesity in SA are limited in their study design. Remarkably, there is a lack of longitudinal studies, and most studies use a cross-sectional design.

2.7.2.1 Dietary intake

The growth in the prevalence of obesity and overweight in children is linked to changes in food consumption habits. Regarding eating patterns in SA, there has been a movement from relying on traditional meals to relying more on Western foods. Carbonated beverages and junk food are all the trends with today's children.¹⁶² Saudi children aged 14 to 19 years who are obese consume fewer vegetables and fruit than their normal-weight peers (aOR=for < 3 times/week = 1.29).¹⁶³ Furthermore, a recent review of 12 studies (10 cross-sectional, one case-control and one retrospective) examining factors impacting obesity among children and adolescents aged 2 to 22 years in the Gulf countries reported that obesity among Saudis is related to unhealthy diet behaviours such as high consumption of fast food, the big portion size of food, and meal skipping.¹⁶⁴ Moreover, a systematic review of 8 cross-sectional studies examined how missing breakfast influences overweight/obesity among Saudis aged 5 to 24. The review reported a significant positive association between missing breakfast and obesity among the target population.¹⁶⁵ However, the review's eight cross-sectional articles were of low quality.

2.7.2.2 Physical activity and sedentary behaviours

A cross-sectional survey involving nearly 900 children aged 6 to 15 years reported that Saudi youngsters go to and from school by automobile and invest more time using video

games or watching television (TV) than they do playing outside.^{166,167} Meantime, a decrease has been seen in children's levels of PA, as shown in a cross-sectional study of nearly 2900 children aged 14 to 19 years that found obesity/overweight was negatively associated with PA (aOR=0.69).¹⁶³ A recent cross-sectional study of nearly 200 Saudi students reported that both genders had significant inverse relationships with most anthropometrics and time spent watching TV and working at a desk.¹⁶⁸ Moreover, screen time was also associated significantly with Saudi obese/overweight children.^{164,169-171}

2.7.2.3 Sleep

Though Saudi children are suffering from an epidemic of overweight and obesity, very few studies have examined the relationship between sleep patterns and weight gain in this population.¹⁷²⁻¹⁷⁶ Sleep duration is also another lifestyle variable related to obesity among Saudi children. A cross-sectional study of nearly 2,850 students in the three major Saudi regions reported that enough sleep duration enhanced the likelihood of maintaining a healthy weight among children aged 15 to 19 years (aOR = 1.28). In contrast, insufficient sleep duration was strongly linked to increasing the risk of being obese or overweight.¹⁷²

2.7.2.4 Socio-economic factors

Several cross-sectional studies examined the association between SES and obesity among Saudi children. Childhood overweight and obesity were found to be increased with higher SES levels,^{177,178} which supports the international literature that childhood obesity is associated with higher SES in developing countries. Paternal occupation and obesity have also been significantly associated with obesity among Saudi children.¹⁷⁰ Being overweight or obese was more common among children having educated mothers, with a three-fold increased risk when having university-educated mothers.¹⁷⁷

To sum up, the Saudi research on the aforementioned risk factors was cross-sectional, and no systematic review of published data on modifiable risk factors for childhood obesity exists. Therefore, it is critical to synthesise all available research on childhood obesity causes in this country. Furthermore, carrying out a systematic review of modifiable risk factors for obesity among Saudi children is crucial for establishing culturally appropriate preventive interventions since results from other countries may not apply to Saudi children.

In addition, the importance of assessing community readiness in childhood obesity prevention is reported in the international literature.^{179,180} There are several conceptions of change readiness,¹⁸¹⁻¹⁸³ and various tools for determining community preparedness for a particular topic or problem.¹⁸⁴⁻¹⁸⁶ However, this kind of assessment of the community's readiness to address obesity is lacking in the Saudi research, which may hamper our understanding of the community's capacity and willingness to change.

2.8 Understanding the complexity of obesity

Obesity has been identified as a system problem for various reasons, including global scope, heterogeneity, complex\wide-ranging impacts, complex causes and finally, the failure of a single solution. The following subsections briefly describe these reasons.

2.8.1 Global scope

Obesity affects countries of all economic levels, not just those at the top and centre of the income scale. Since the afflicted people and nations are so diverse, the pandemic could not be attributed to a single element at the individual level, such as food overconsumption. Obesity needs to be addressed through a systemic approach that understands the underlying, system-level drivers.^{153,187,188}

2.8.2 Obesity heterogeneity

Across and within different nations, there are unexplainable patterns of heterogeneity. Even though worldwide obesity rates have more than quadrupled since 1980, not all nations, even those nearby, have been equally impacted.^{11,189} In fact, obesity trends in a given country might vary greatly across its various demographics. For example, the issue of obesity among children in the UK is particularly prevalent in urban areas.¹⁹⁰ In addition, the prevalence of obesity has risen significantly among several socioeconomic categories. For example, in the UK, black children (10 to 11 and 4 to 5 years) have a higher overweight rate than any other ethnic group.¹⁹¹ Obesity does not seem to result from a direct cause-and-effect connection, as seen by these diverse and complex patterns.

2.8.3 Complex and wide-ranging impacts

A broad range of social, psychological, biological and physiological consequences may be attributed to obesity. These include certain types of cancer, type 2 diabetes, hypertension, and other mental and social issues. A person's sleep habits, productivity, and self-esteem may be affected by obesity.⁵⁷ Numerous of these obesity-related effects and consequences lead to the development of life-threatening illnesses and place a financial burden on whole communities, including people and third taxpayers.¹⁹²

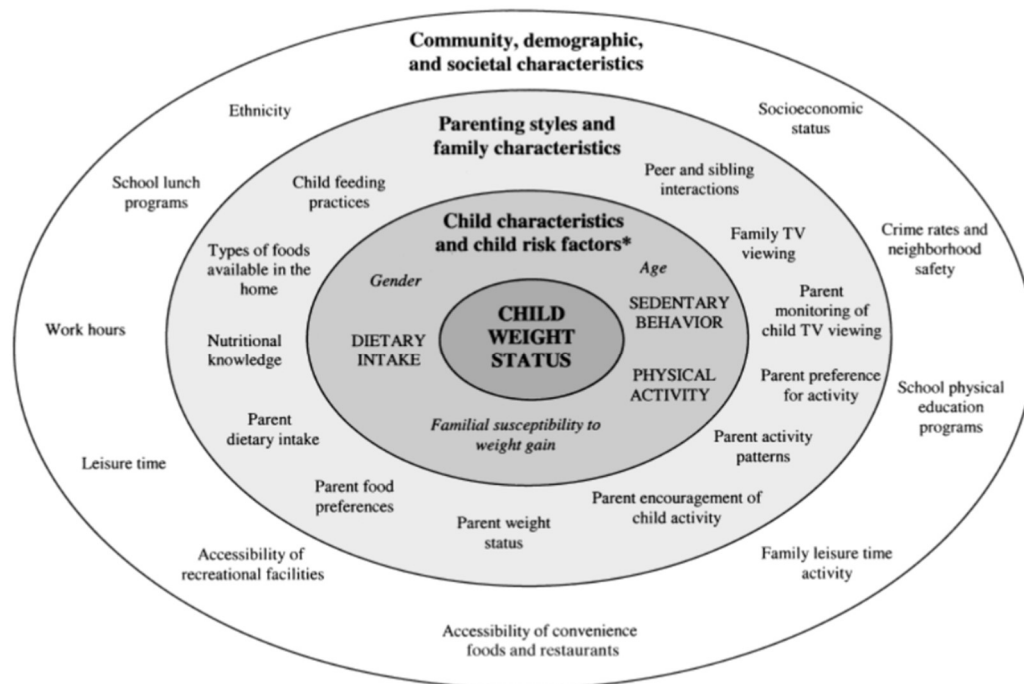
2.8.4 Complex causes

Research on obesity has not identified a specific cause for the obesity epidemic.¹⁹³ In reality, it is the product of a complex collection of elements that function and interact at many societal levels or contexts.¹⁸⁷

Several frameworks have been developed to show the interrelated and complex causes that might lead to obesogenic behaviours and contribute to obesity among children. One

of these models was the contextual model proposed by Davidson and Birch in 2001.¹⁹⁴ The model used the Ecological Systems Theory proposed by Bronfenbrenner in 1979¹⁹⁵ to try conceptualising the development of obesity among children. Davidson and Birch's model is shown below in Figure 2-1, which highlights several determinants that can influence the development of obesity and/or overweight among children. However, Davidson and Birch's model and other models, like those proposed by Tabacchi et al.¹⁹⁶ and Neumark-Sztainer¹⁹⁷ are limited by their focus on the environmental influences and/or particular developmental periods.

Figure 2-1: Davidson and Birch's model

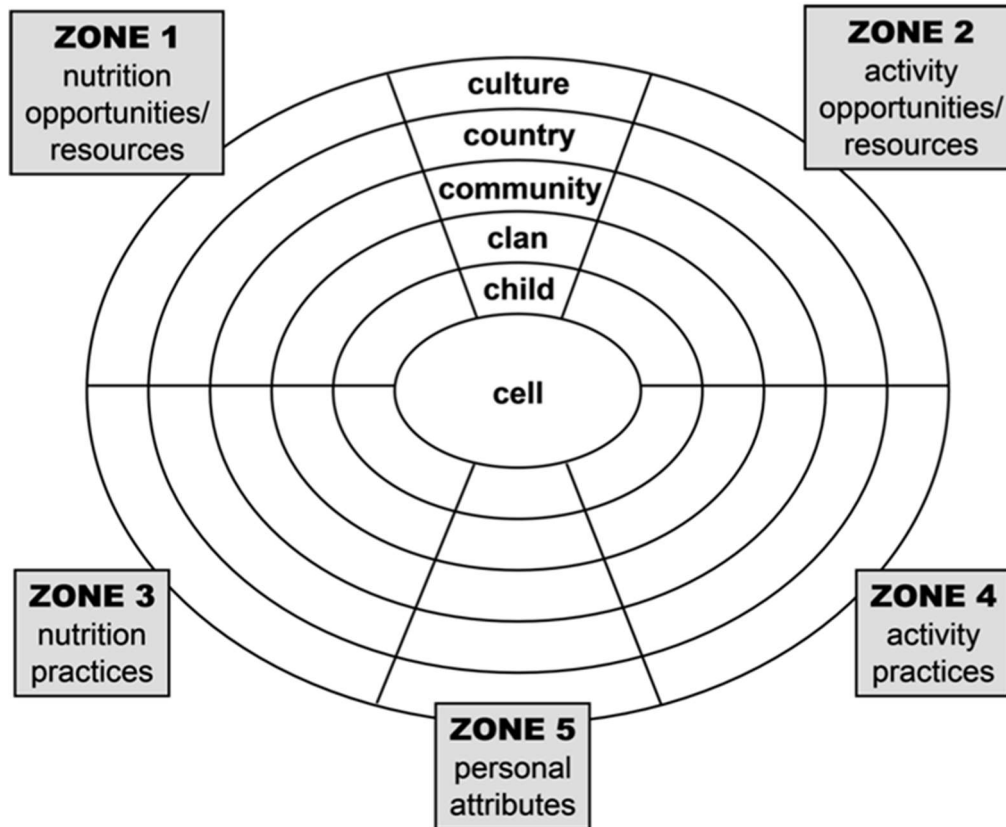


Source: Davidson and Birch (2001)

In 2011, Harrison et al.¹⁹⁸ extended the previous work by proposing a new framework called the 'Six Cs' model that summarises the elements contributing to obesity in children (Figure 2-2). The model consists of six Cs, including Culture (myth, norm, bias), Country (policies, priorities, programmes), Community (peers, schools), Clan (family

characterises), Child (child characteristics) and Cell (genetic, biological). All of these Cs interact with each other contributing to childhood obesity.

Figure 2-2: The 'Six Cs' model



Adopted from Harrison et al. (2011)

Another feature of the numerous causes of obesity is that the link between any two variables is not always straightforward. For example, some studies examined peer influences on children's diet and PA. For diets, findings show that supporting dietary habits among peers may decrease children's intake and may be increased by social and emulation facilitation.¹⁹⁹ In addition, findings show that peers' motivation and rewarding value can increase children's PA. Peers also can decrease children's PA through ostracism, isolation, peer-victimisation, and isolation from their peers.²⁰⁰

2.8.5 The failure of single solutions

Since the design and implementation of several obesity-prevention programmes that focus on one or a few causes, obesity rates have continued to climb.¹¹ Meanwhile, programmes using multilevel and multicomponent (MLMC) interventions, such as Shape Up Somerville, have appeared successful.²⁰¹ However, the processes that underlie their failure, success and sustainability remain largely unknown.^{202,203}

2.8.6 The Foresight Obesity System Map

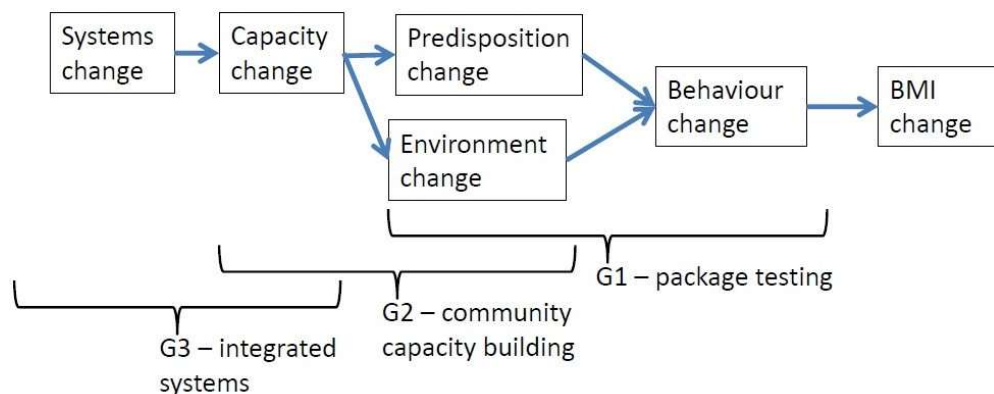
The 2007 Foresight project aimed to improve the understanding of the UK government on the obesity epidemic and assist policymakers in developing and evaluating policy options.²⁰⁴ The final model contained over 105 elements connected by around 300 connections. Each variable was grouped into seven thematic clusters: food consumption and production, engine, PA environment, individual PA, and social and individual psychology. The foresight map exhibits that any action by an element of the system can affect the flow out or into that element. The foresight map depicts several factors that lead to obesity in a balanced and reinforcing manner.

As a result of publishing the Foresight Map, obesity prevention experts and researchers have noted that traditional approaches that concentrate only on a specific intervention and the individual level have been displaced. With the Foresight Map, it can be seen how traditional efforts at childhood obesity prevention are failing. Hence, I reviewed past and current approaches to childhood obesity prevention to select the most promising approach for the prevention intervention programme.

2.9 Generations of approaches

In preventing childhood obesity, three major approaches have been used: package delivery, capacity building and systems-based approaches.^{205,206} These approaches and their properties are shown in Figure 2-3.

Figure 2-3: Generations of approaches



Source: Swinburn, B. (2015)

2.9.1 Package delivery approach

This kind of approach is the most often employed in the field of obesity prevention. It is a collection of evidence-based interventions meant to address the proximal factors contributing to obesity, including knowledge, behaviours and the local environment. A cluster randomised controlled trial (cRCT) is the most often designed to implement and evaluate the intervention package in this approach. Interventions in this approach are often brief (1-2 years) in length to correspond to the research funding period.²⁰⁵ This short-term implementation raises a concern regarding its sustainability. A qualitative study exploring obstacles and enablers of a three-year school-based obesity programme reported that sustainability might depend on providing funding from states and offering technical help.²⁰⁷

Moreover, a recent systematic review of 24 school-based intervention studies concluded that the sustainability of health promotion programmes in schools rests on the school's capacity to attract and maintain highly qualified administrators and employees committed to providing health promotion in the face of constantly shifting conditions.²⁰⁸ A cRCT of 12 months programme of children aged 7 to 11 years found that despite substantial changes in children's BMI between the intervention and control arms, these changes were shown to be unsustainable after two years of follow-up.²⁰⁹ Similarly, the home-based interventions programme revealed that the substantial impact of their interventions had faded after three years.²¹⁰

The effectiveness of this approach is inconsistent, and high-quality evidence is needed. A recent systematic review and meta-analysis of 48 RCT studies assessing the effectiveness of school-based interventions revealed that a slightly favourable impact in the control group was seen compared to the intervention group (2.14; 95% CI = 0.77, 3.50), and other behaviours, such as consumption of fruit/vegetable, sedentary activities and energy intake were not affected.²¹¹ Moreover, a review of 12 cRCT concluded that school-based interventions could reduce BMI and BMIZ scores among children aged 6 to 18 years. However, the evidence quality is low due to inconsistency and the high risk of bias.²¹²

A recent umbrella review of 14 systematic reviews revealed a more optimistic picture regarding family-based interventions. The review concluded that all reviews except one did not show any improvement in children's weight and/or behaviour.²¹³ This review should be interpreted cautiously since all included reviews were of low to moderate quality. The absence of high-quality evidence employing the packaged delivery approach has been reported in two other reviews.^{212,214}

2.9.2 Capacity building approach

Intervention programmes of this approach concentrate on enhancing community capacity, fostering alliances, enhancing worker skills, mobilising resources, encouraging leadership, and strengthening monitoring and evaluation.^{215,216} This approach develops strong collaborations among researchers and practitioners. It is more sustainable and embraces a variety of settings and strategies. This approach has a low internal validity due to the use of quasi-experimental design in the evaluation of its interventions.²⁰⁵

This approach has been successful and sustained in lowering obesity among white children in AUS and the US.²¹⁷⁻²¹⁹ Additionally, these programmes were proven to be 'viral,' spreading the anti-obesity message to neighbouring communities.²²⁰ However, three different community efforts in New Zealand, Tongatapu and Fijian, revealed that this approach was unsuccessful in reducing obesity among children aged 9 to 19 years.²²¹⁻²²³ Additionally, Being Active Eating Well, an Australian effort to encourage healthy eating and PA among children, was adapted to five new distinct community settings. Authors found that lower results related to weight were found only in one community.²²⁴ There is an emphasis on considering the SAP, modifying current systems rather than introducing new ones in the future.^{224,225}

Sustaining obesity intervention programmes using a capacity-building approach is a major challenge. It is rare for the long-term outcomes of community-based initiatives to be examined and reported.²²⁶ Community-based obesity interventions have been evaluated under tightly controlled situations that are difficult to sustain and scale after finishing the research,²²⁷ making the sustainability of such programmes still unknown owing to the complexities of obesity.

2.9.3 Systems-based approach

This approach is derived from the overlap of complexity and systems theory disciplines. It is considered a way to address complicated issues by considering the entire rather than individual components and focusing on the interconnections and feedback loops among many components. This approach has been around for over 50 years. Cardiovascular disease,²²⁸ mental health,²²⁹ and tobacco control²³⁰ have benefitted from this approach.

There are rising demands to employ this approach in the fight against obesity since previous efforts have failed to create an effective and, most crucially, sustained impact of the intervention due to a major lack of methods and tools that can identify and comprehend the complex nature of obesity. As a result, it was proposed that any new approach to addressing obesity must consider this intricacy.^{231,232}

At a community level, using the systems-based approach to reduce obesity in children seems likely to be a promising approach, as this approach is capable of describing nonlinear dynamics between elements within complicated systems, feedback mechanisms, time-delayed effects and the unexpected consequences of intervention in these systems. Additionally, it is possible to use this approach to identify ways in which existing community contexts and systems can be utilised or repositioned in order to improve health results by first examining how they are currently implemented in the community under study and then working collaboratively with local experts and community members to understand the multilevel drivers of obesity.²³³ Optimising implementation of this approach requires thoroughly considering various systemic elements such as economic, social, leadership, political and cultural factors.²³⁴

2.9.3.1 Components of the systems approach

There is uncertainty about the components of this approach because it is still in its infancy. Moreover, researchers are confused about differentiating between community-based interventions (CBI) that use MLMC on the one hand and community-based systems interventions (CBSI) on the other hand. CBI that aligns with the capacity-building approach entails leveraging and reinforcing current networks and features. However, CBSI also falls within this definition, but it also extends to add the term ‘systems’, which involves recognising multifaceted and dynamic systems instead of presuming the linear relationship and concentrating on individual isolated aspects.^{235,236}

A unique example of CBSI is the Whole of Systems Trial of Prevention Strategies for Childhood Obesity (WHOSTOP), launched in AUS in 2016. This programme used the CBSA supported by systems thinking in the design, delivery and evaluation.²³³ The WHOSTOP expands on the definition of capacity building by conceptualising obesity as a complicated issue to generate a new possible solution, developing a detailed systems map to comprehend how to use current relationships/resources and using a dynamic logic model.^{233,237}

Establishing a steering committee formed from the local leaders is another critical component of CBI. This steering committee aims to ensure implementation success through increasing community outreach and engagement and developing motivation for transformation. Leaders must disseminate the intervention throughout the community in order to accomplish systemic change.^{238,239} In systems interventions, dissemination from this committee to the general public is critically dependent on the involvement of leaders concerning childhood obesity prevention, knowledge of leaders towards addressing childhood obesity and the strength of internal and external networks to the committee.²³⁹

Steering committee members are chosen based on their demonstrated abilities to improve children's settings using their current position. It is critical to have a shared understanding of the system and recognition of the leader's role in a complicated system.^{235,237}

2.9.3.2 Tools of the systems approach

Various tools are used to assist communities when using the CBSA, including GMB, agent-based models and social network analysis. Table 2-2 briefly introduces these tools and their strengths and limitations.

Table 2-2: A summary of systems approach tools.

Tools	Description	Strengths	Limitations
GMB	It is a System Science tool that is done in a workshop structure to bring together various stakeholders in joint exercises to develop a dynamic model called a casual loop diagram (CLD). ²⁴⁰ (Described in detail in Chapter 7).		
Agent-based modelling	A computational tool that simulates agents' interactions and enables the examination of dynamic processes that connect individuals' behaviour to the overall results among communities. ²⁴¹	<ol style="list-style-type: none"> 1. Possible to depict in graphical representations. 2. Simulation of a variety of scenarios in order to test a wide range of intervention methods.²⁴² 	<ol style="list-style-type: none"> 1. Practical challenges to using it for public health include the dearth of training among researchers and students and the substantial amount of time and computer resources required.²⁴³ 2. Difficulties with model parameterization and validation and defining its proper scope.²⁴³ 3. Difficulty interpreting outputs when there are large numbers of causal factors.²⁴⁴
Social network analysis	A method to investigate the impact of social structure on an issue of interest. It investigates how social relationships among individuals are linked to a specific result. ²⁴²	<ol style="list-style-type: none"> 1. visualisation of subject-to-subject interactions and relationship patterns, and the emergent process that results, which helps formulate effective policies.^{245,246} 	<ol style="list-style-type: none"> 1. The emphasis is on the impact of interpersonal interactions rather than individual qualities, surroundings, context, and time. 2. Difficulty generalising its data because it focuses on a specific social group.²⁴²

2.9.3.3 Effectiveness of a systems approach

Even though there are rising demands for this approach to obesity prevention, a few programs have started to use it, and most of them are currently in development. As a result, the effectiveness of this approach is limited and described in detail in the scoping review (Chapter 4).

2.9.3.4 Evaluation of a systems approach

Evaluation of interventions is crucial to assess the effects on certain chosen outcomes. Changes in BMI and health behaviours have been the most commonly evaluated prevention intervention outcomes.²³⁸ Moreover, since it is difficult to measure changes in a population accurately, many community-based obesity prevention programmes rely on existing data such as school-based data or national data,^{247,248} and self-report measuring tools that are subjected to biases.²³⁸

Since traditional methods of measuring outcomes may not reveal the sorts of processes that contributed to the observed outcomes,²³⁸ combining traditional methods of outcome measure with process evaluation (that gives insight into successful processes for decision-making and structuring throughout the implementation stage) was recommended.^{238,249} However, measurement and tracking systems-based intervention is challenging due to the nonlinearity and complexity.^{238,250} New ways to evaluate public health initiatives are needed to focus on systems-based interventions containing elements that are greatly combined and more complex compared to more straightforward linear approaches.²⁵¹ It is not that the intricacy of public health issues is not comprehended, but there is an inability to apply our comprehension in practice.²⁵² Clearly, there is much need for new techniques to evaluate systems-based interventions.

2.10 Research and efforts on childhood obesity prevention in Saudi

Arabia

Before 2019, SA's government, in collaboration with a few private sectors, established a number of significant strategies and/or programmes to address the country's obesity epidemic.²⁵³ Noticeably, the Ministry of Health (MoH) is responsible for most policies, initiatives, and programmes to combat obesity. Table 2-3 below, which outlines the most significant efforts to combat obesity, clarifies that there is no lack of efforts to reduce obesity and overweight in the country. However, most of those efforts had a limited implementation period and were not evaluated. Additionally, several initiatives had no specific action plans other than the fact that they were announced/introduced.²⁵⁴ Notably, all the efforts listed in Table 2-3 are being carried out nationwide. Noticeably, those programmes were traditional approaches that relied on educational interventions at the individual level.²⁵⁴

Table 2-3: Obesity related strategies/initiatives/programmes in SA.

Title	Type	Date launched	Brief description
Movement is a Blessing ²⁵⁵	Programme	2004	This was a national PA programme implemented within schools for children aged 6 to 12 years. It provided children, their families and teachers with knowledge and skills on PA. Components of the programme included written materials, a webpage and a digital CD.
Fitness ²⁵⁶	Programme	2017	This was a national programme aimed at reducing obesity rates among school children.
Saudis are walking ²⁵⁷	Initiative	2017	This is a voluntary awareness initiative to urge the community to practice walking.
Health-promoting schools	Initiative	2004	This was a global initiative sponsored by the WHO to implement a holistic approach to improving schools' health.
Combat Obesity and Promote Physical Activity in the Arab Countries ²⁵⁸	Strategy/policy	2011	This was implemented due to the 3 rd Arab conference on PA and obesity. As a result, each Arabic country had guidelines and recommendations prepared to suit its context and targeted several areas such as schools, the food industry and media.
Diet and physical activity ²⁵⁹	Strategy/policy	2014	This policy aims to support the health of individuals, communities and the nation through establishing a monitoring system for risk factors, partnering with other sectors, empowering and enacting laws and raising awareness of public health directors.
Obesity control ²⁶⁰	Programme	2014	This is a national programme to combat obesity by promoting community health in different age groups in the country.
Prevention and management of obesity ²⁶¹	Guidelines	2016	This guideline provides recommendations on addressing obesity and overweight among adults and children that suit the country's context.
Saudi vision 2030 ²⁶²	Strategy/policy	2016	A part of this vision was launching the quality-of-life programme to lower obesity rates by increasing engagement in sports and other related activities.
Healthy food ²⁶³	Strategy/policy	2018	This comprehensive policy aims to reduce trans and saturated fatty acids in food.

There is also a lack of longitudinal and/or intervention studies exploring how to reduce the obesity epidemic. Only one school-based intervention trial was conducted in 2020 that investigated the efficacy of a healthy lifestyle intervention among girls aged 12 to 15 years.²⁶⁴ PA and dietary habits were improved significantly in the intervention group. The intervention group had a 3.4 % decrease in obesity prevalence, whereas the control group had an increase of 1.4%. Recently, there have been a number of obesity-related policies that SA is either already adopting or is planning to enact. There has been a clear trend towards adopting upstream interventions targeting issues beyond individual factors. Table 2-4 outlines the current policies in the country.

Table 2-4: Policies to address obesity in SA.

Policy	Year Implemented	Policy type
Showing Calories information on foods and drinks ²⁶⁵	2019	Mandatory
Excising tax 50% on sugar-sweetened beverages ²⁶⁶	2019	Mandatory
Excising tax 100% on energy drinks ²⁶⁶	2019	Mandatory
Displaying nutrition labels on the front (traffic light) ²⁶⁷	2021	Mandatory
Banning hydrogenated oils in food ²⁶³	2020	Mandatory
Offering PE classes to girls in schools ²⁶⁸	2019	Mandatory
Requiring "added sugar" to be included on nutritional labels ²⁶⁹	2021	Mandatory
Banning artificial additives in milk, yoghurt, and fruit juices served in school canteens ²⁷⁰	2019	Unknown
Setting a maximum amount of 22 grams of sugar in milk and yoghurt served in school canteens ²⁷⁰	2019	Unknown
Setting a minimum of 30% fruit juice content in juices served in school canteens ²⁷⁰	2019	Unknown
Banning certain food products in school canteens ²⁷⁰	2019	Unknown
Granting a license for female gyms ²⁷¹	2019	-

Even though it is too early to examine the impact of the policies outlined in Table 2-4 on childhood obesity, one study has recently been undertaken to assess children's behavioural outcomes. In a repeated cross-sectional study of 787 children aged 12 to 14 years, the percentage of children who drank energy drinks before and after introducing a tax on SSBs dropped by about 8%. However, once the tax was implemented, children's consumption of soft drinks increased by 2%.²⁷² Furthermore, a countrywide inspection campaign targeting coffee, juice, and restaurant outlets revealed that around 60% of outlets omitted calories from meal options and/or utilised sweeteners to make juices.²⁶³

On paper, SA has made great efforts to implement obesity-related policies. However, one of the most pressing issues is the absence of evidence before and during a policy's adoption.²⁵³ Evidence of this kind is required to assess the effect of a policy. Another issue is that stakeholders are not held accountable for implementing, monitoring, and evaluating specific goals. Whichever party is in charge of making sure that progress is being made remains a matter of controversy. Despite the inclusion of stakeholders in the plans, it is not apparent how the various sectors would work together to guarantee implementation and assessment.²⁵³

SA requires a plan owned and delivered by diverse sectors to affect risk factors for NCDs from local to national levels.^{166,253,254} In addition, other stakeholders should be included in the plan, and new partnerships should be created. These stakeholders include urban planning, media, agriculture, sports, education, and rural and municipal affairs to ensure that interventions reach all levels and areas where people live and work.²⁵³ Multi-sectoral commitment and consensus are required to create such a plan.

2.11 Summary and justification

2.11.1 Key findings

2.11.1.1 Gaps in international literature

The literature review indicated that the few empirical studies attempting to apply the CBSA in childhood obesity interventions are based on Western populations. This raises concern regarding the feasibility of applying the CBSA to developing childhood obesity prevention interventions in non-western nations. This led to the development of the main goal of this thesis- *To assess the feasibility of applying systems approach to developing childhood obesity prevention interventions in Makkah, SA.*

Moreover, the literature review clearly indicates that despite the concepts and terminology of systems approach existing for several decades, empirical knowledge about their application and effectiveness for obesity prevention is limited, meaning that more clarity is required regarding what systems-based obesity prevention interventions look like in practice. Furthermore, carrying out a scoping review of empirical studies that comprehensively applied the systems approach to obesity prevention is crucial for future work on how to apply the systems approach truly. Hence, one of this thesis objectives was to carry out a scoping review to identify what has been achieved to date regarding applying a comprehensive systems approach to obesity prevention.

2.11.1.2 Research gaps in SA

The literature review indicates that the Saudi research on the risk factors associated with childhood obesity mainly was cross-sectional studies, and no systematic review of published data on modifiable risk factors for childhood obesity exists. Therefore, it is critical to synthesise all available research on childhood obesity causes in this country. Furthermore, carrying out a systematic review of modifiable risk factors for obesity

among Saudi children is crucial for establishing culturally appropriate preventive interventions since results from other countries may not apply to Saudi children. Hence, one of this thesis's objectives was to review modifiable risk factors for obesity among Saudi children systematically.

Moreover, the literature review revealed a complete lack of research to enhance our understanding of the readiness of the Saudi community to address childhood obesity. To address this gap, one of the thesis's objectives was to assess the readiness of a Saudi community to address childhood obesity.

2.12 Aim and research questions

The literature review leads to develop the following main aim of this thesis:

To assess the feasibility of applying a systems approach to developing childhood obesity prevention interventions in Makkah, SA.

The following inter-related research questions were set to fulfil the main aim of this thesis:

- a) What are the modifiable risk factors of obesity among children aged 2-18 in SA?
(Chapter 3)
- b) What has been achieved to date in terms of applying a comprehensive systems approach to obesity prevention? (Chapter 4)
- c) What is the current stage of readiness in addressing childhood obesity among the Makkah community? (Chapter 5)
- d) What are the decision-makers' perceptions of potential barriers and enablers to developing systems-based interventions within the Saudi community? (Chapter 6)
- e) What is the most feasible and appropriate way to organise and conduct 'Group Model Building' workshops within the Saudi community? (Chapter 7)

2.13 Justification for focusing this PhD study on a systems approach to childhood obesity prevention

The literature review (Section 2.8) shows worldwide research on the complex nature of obesity in children, and the failure and limitations of past and current approaches to preventing childhood obesity. This extensive literature review influenced the critical choice to select the CBSA for this PhD research. The three subheadings below summarise the key reasons to focus this PhD study on this approach.

2.13.1 The systems nature of obesity

The systemic nature of obesity, as discussed in Section 2.8, is one of the key reasons for choosing CBSA to childhood obesity prevention in this PhD. Interconnected feedback loops, delays, overlapping, dynamicity, nonlinearity, heterogeneity and multi-faceted causes have been described above as the characteristics of obesity as a complex system. To successfully address obesity, it is vital to underline that the approach employed should acknowledge the complexity of obesity by emphasising the larger context, considering connections among numerous levels, identifying dynamic processes, and fostering cooperation among various stakeholders. In fact, the needed characteristics of the approach taken to address obesity are indicative of the SAP, which offers a variety of methods/tools for de-mystifying obesity's complexity. Those methods may investigate the factors contributing to obesity, their relationships, and how they evolve over time. The essential component of this approach is the usage of a CLD, which is based on GMB, a participatory method (discussed in greater detail in chapter 7). These CLDs visualise the various factors contributing to obesity and their interrelationships via many feedback loops. CLDs aid in investigating the causal structure of obesity, identifying feedback mechanisms and 'leverage points' that yield the desired result(s). Past obesity prevention

approaches could not fully account for the complex web of interactions and linkages contributing to obesity. In contrast, the systems-based approach and its accompanying tools may help researchers comprehend the intricacy of the drivers of childhood obesity listed in Section 2.8 more clearly and effectively.

2.13.2 The effectiveness and sustainability of past approaches

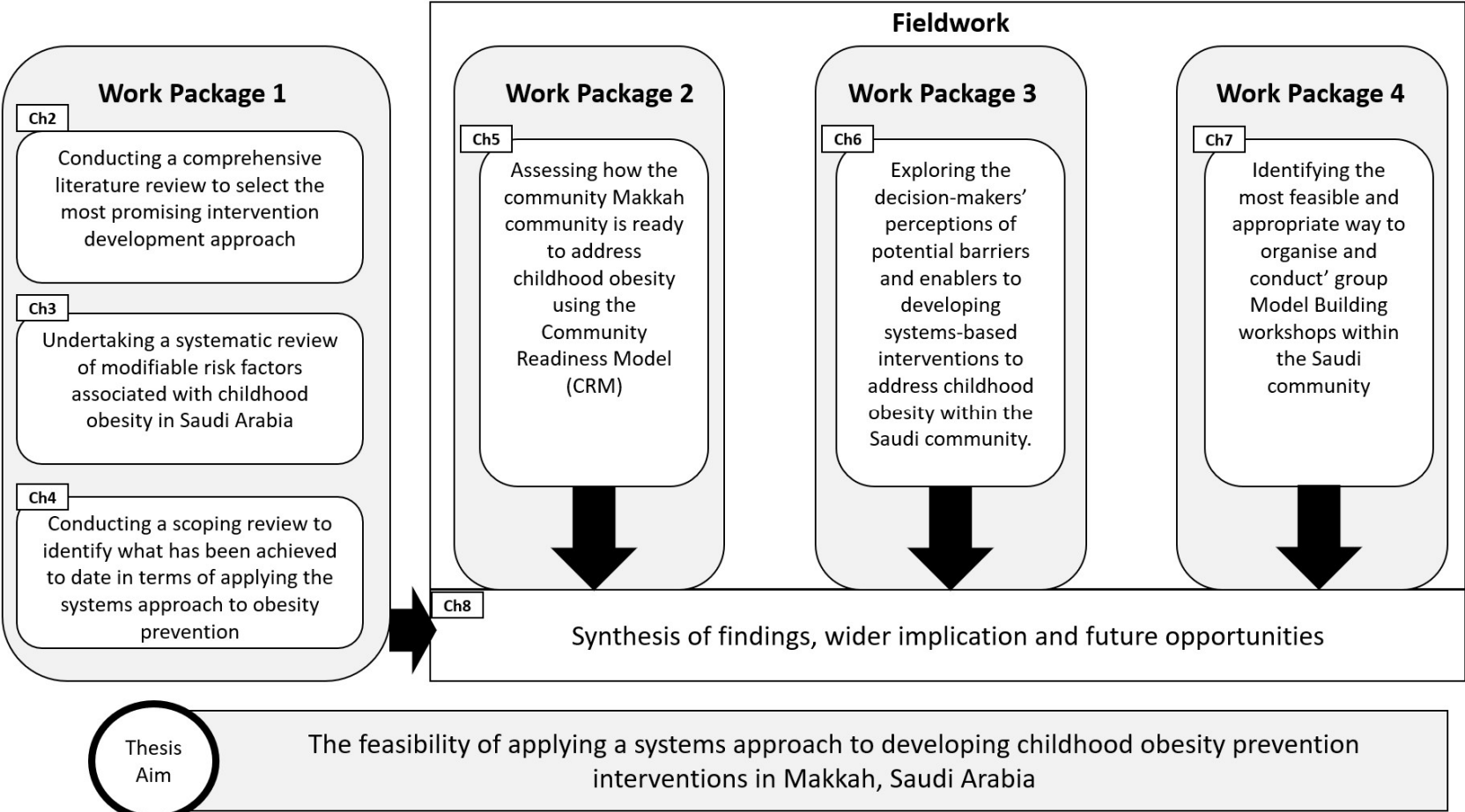
The scoping search of past approaches to childhood obesity prevention detailed in Section 2.9 indicates that the effectiveness and sustainability of packaged delivery and capacity-building approaches are limited. Consequently, CBSA has been suggested as a possible approach for ensuring the sustainability of obesity prevention since it entails the employment of a successful tool—CLD. This tool depicts the obesity system's feedback loops and delays in a simple form to comprehend. Comprehending these processes (feedback and delays) and the structure and dynamics of a given community may enhance designing an effective and sustainable intervention to address childhood obesity. Furthermore, effective and sustained interventions may be achieved using a systems-based approach. It enables a broader understanding of unexpected effects, constructs logic models that go far beyond linear relationships, and allows for exponential change by identifying leveraging points.²³⁷

Taken together, the systems approach allows us to understand the complex interactions within diverse causes of obesity as a system, and to see the causal loops within obesity-promoting systems which generate and moderate certain behaviours. Understanding the process and mechanisms of feedback loops and the delays incorporated in a CLD can help design effective and sustainable interventions to prevent childhood obesity.

2.13.3 Fitting the Saudi context

Based on the scoping search of the prevention of childhood obesity in SA (section 2.10), an approach that leads the process of preventing obesity in children is obviously needed. The characteristics of the integral approach in SA are almost applicable to the systems-based approach. The country needs an approach based on the principle of integration and collaboration among stakeholders and leading the implementation, evaluation and monitoring process, as well as clarifying the role of each stakeholder.

Figure 2-4: A diagram of the PhD aim and objectives



2.14 Chapter summary

This chapter discussed the global trends in childhood obesity, its consequences, causes, and economic burden. In addition, the issue of obesity among Saudi children and prevention efforts were also articulated. Evidence proved that childhood obesity is a system issue driven by interactions of complex factors, including environmental, social/cultural, political, economic, and behavioural dimensions. Moreover, generations of approaches to childhood obesity prevention were also discussed. Evidence showed that all previous traditional approaches to obesity prevention, e.g., packaged delivery, have failed in terms of effectiveness and sustainability. As a result, there have been growing interest and investments in a systems-based approach to tackle complex public health issues, including childhood obesity. A few empirical studies have attempted to truly apply system thinking in public health interventions. The promising role of a systems-based approach in addressing childhood obesity was presented. The leading motivation for applying this approach is its ability to identify and embrace the complex nature of obesity through the use of its tools. However, all empirical studies using this approach are based on western populations.

This chapter also explained why this PhD study focused on CBSA and how the extensive literature review influenced this critical choice. Clearly, there is a lack of evidence on the feasibility of applying CBSA within non-Western populations. Moreover, research gaps in SA were also articulated, indicating the need to synthesise all available research on risk factors associated with obesity among Saudi children and assess the Saudi community's readiness to address childhood obesity. Finally, the thesis's main aim and objectives were presented.

Chapter 3: Modifiable risk factors of obesity among children aged 2 to 18 years in Saudi Arabia: Using the Socioecological Model

3.1 Chapter overview

This chapter details a systematic review of the published literature regarding the modifiable risk factors associated with obesity among Saudi children aged 2 to 18 years. This study addressed the first objective of this thesis: *What are the modifiable risk factors of obesity among children aged 2-18 in SA?* The results of this review are also reported in alignment with a discussion of the key findings of the previous literature. This review found that previous etiologic research in this country has predominantly focused on individual-level risk factors with a lack of research on policy, environmental or community-level factors. Evidence on the association between commonly reported modifiable risk factors and childhood obesity is inconsistent and conflicting.

3.2 Introduction

As shown in the literature review, the prevalence of childhood overweight/obesity in SA is growing rapidly. The latest available national statistics (based on the WHO 2007 criteria) showed that the prevalence of overweight among the 5–18 years old is 23.1%, with an additional 9.3% and 2% being obese and severely obese, respectively.²⁷³ This has led to an increasing number of studies to identify modifiable risk factors in this country.

To date, three reviews have examined risk factors of childhood overweight and obesity in Middle Eastern countries (MECs)^{274,275} and one in SA.²⁷⁶ Specifically, a systematic review and meta-analysis included 56 articles on the prevalence and risk factors of obesity among people under 20 years in the North Africa and Middle East region (18 countries). 87.5% of those studies were cross-sectional, 12.5% were reviews, randomised controlled trials, and quasi-experimental and retrospective cohorts. Only two studies conducted in SA were included in this review. The

review found a higher prevalence of overweight and obesity among males than females in SA. In addition, their meta-analysis concluded that higher social class, increased screen time (ST) and lack of PA were major factors associated with childhood obesity in all countries.²⁷⁴ However, the reviewers did not provide clear information on how they assessed the quality of the included studies. Moreover, the timeframe of the included studies was limited to five years (2010 to 2015), which may not offer a complete evidence synthesis for risk factors, and more recent studies (post-2015) may be of higher quality, so they are worth investigating.

The 2018 systematic review of four cross-sectional studies (rated as good quality) examined the dietary factors associated with obesity and overweight among children aged 6–12 years in the MECs. Excessive fat intake, skipping breakfast, and low consumption of milk, vegetables and fruits were positively correlated with the risk of childhood overweight and obesity.²⁷⁵ However, this review was limited by focusing only on dietary factors.

A further review was conducted to investigate the association between breakfast skipping and obesity among Saudi children aged 5–24 years. It concluded that missing breakfast is associated with a greater risk of childhood obesity.²⁷⁶ However, the poor quality of the eight cross-sectional articles in their review limited their findings.

Clearly, no systematic reviews have specifically studied modifiable risk factors of obesity across a widespan of childhood in SA. A rigorous synthesis of published evidence on modifiable risk factors is needed to understand risk factors for childhood obesity/overweight to inform relevant future interventions for Saudis. The present review is the first effort to characterise and synthesise the existing literature on modifiable risk factors (including behavioural, environmental, SES, or psychological risk factors) of overweight and obesity among children aged 2–18 years in SA. I also mapped review findings onto the SEM to determine which levels of childhood overweight/obesity have been examined extensively and

which still need further research. Findings are expected to inform future research, policies, and programmes to address childhood overweight and obesity in SA and other MECs.

3.3 Aim and research questions

This review aimed to characterise and synthesise the existing literature on modifiable risk factors of overweight and/or obesity among children aged 2–18 years in SA. In order to achieve the main aim of this review, the following two questions were set:

- a) What are the modifiable risk factors associated with overweight and/or obesity among children aged 2-18 years in SA?
- b) Which levels of childhood overweight and obesity determinants have been more frequently studied in Saudi literature?

3.4 Methods

This systematic review used the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)²⁷⁷ as a guideline. The protocol has been registered on The International Prospective Register of Systematic Reviews (PROSPERO); registration number: CRD42019127807.

3.4.1 Search strategy

Systematic searches (Appendix 1) were run in the international (PubMed, Medline, PsycINFO, Web of Science) and national (the Saudi Digital Library) databases from inception to February 2019. The Medline search strategy was adapted and amended for the remaining databases. In addition, relevant Saudi peer-reviewed journals and reference lists of the included articles and systematic reviews assessing risk factors and obesity in MECs were searched by hand. If the full text of an article was unavailable online, the authors were contacted to request the full text.

3.4.2 Study selection and eligibility criteria

Two reviewers independently screened all identified studies' titles, abstracts, and full texts. Results of the full-text assessment were compared, and disagreements were resolved by the principal supervisor (Bai). The Population, Intervention, Comparison and Outcome (PICO) framework was used to guide the study selection:

Population: Studies conducted in SA on children aged 2–18 years residing in SA were included in this review. Studies that involved children out of this age range or were conducted in places other than SA were excluded.

Intervention: Studies on modifiable risk factors, e.g., psychological, behavioural, environmental and socio-economic factors, of childhood overweight/obesity were included. Studies that assessed non-modifiable risk factors, including genetics, physiological and ethnicity were excluded.

Comparator: No exposures to a modifiable risk factor being studied.

Outcomes: Studies in which obesity/overweight was objectively measured, including BMI, waist circumference, body fat percentage and skinfolds were included. Studies that used self-reporting measures of obesity were excluded. In addition, studies that used a reference standard (WHO 2007, CDC, IOTF or Saudi growth chart) were included.

Additional criteria: Observational and experimental studies reported the association between overweight/obesity and any modifiable risk factors, while qualitative studies were excluded. Systematic reviews that included SA children were included to identify relevant primary studies for this review. In addition, studies had to be published in English or Arabic in a peer-reviewed journal and available in full text. Non-peer-reviewed articles; papers with non-

empirical findings; papers published in other languages; and papers for which the full text was unavailable were excluded (if authors did not respond to the request).

3.4.3 Data extraction and quality assessment

Two reviewers independently extracted and recorded relevant data using a customised data extraction form. The form was designed and piloted on a sample of the included articles and improved accordingly. It was used to summarise the data from each study, including general information, study population, methods, key results, levels of SEM addressed and quality score. The completed forms were compared, and disagreements were resolved by the principal supervisor (Bai).

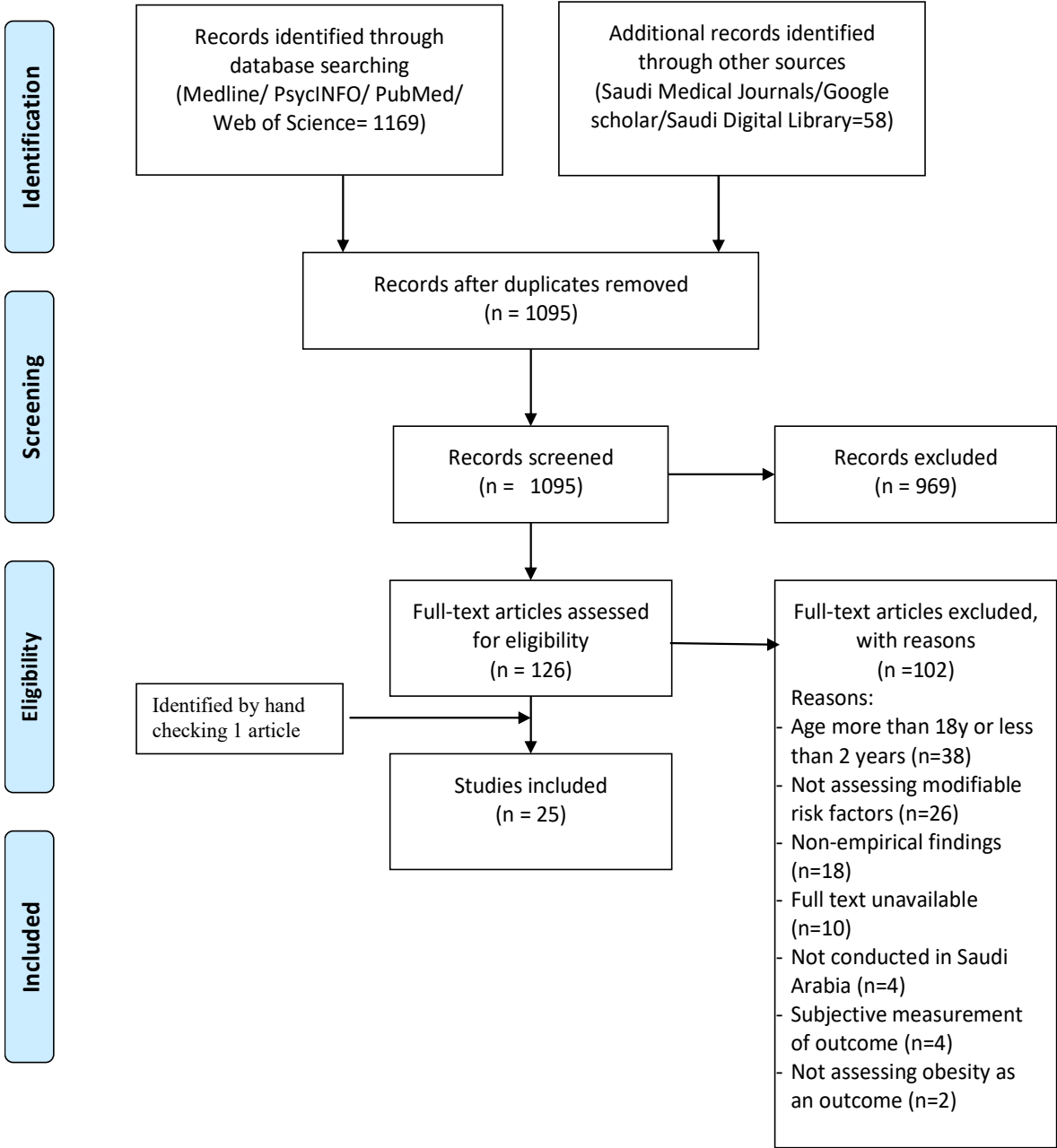
As 24 of the 25 studies were cross-sectional, the Appraisal tool for Cross-Sectional Studies (AXIS)²⁷⁸ was used. This tool was designed to assess cross-sectional studies and addresses study design, quality of reporting and risk of bias. It was also chosen because it focuses on addressing poor reporting, and the studies included in this review were expected to be poorly conducted.

3.5 Results

3.5.1 Study selection

The database searches yielded 1,227 citations. After removing duplicates (132 citations), two reviewers independently screened the study titles, abstracts and full texts. One article was identified by hand-searching the references of the full-text articles.²⁷⁹ Of the 127 articles selected for full-text screening, only 25 were included in this review (Figure 3-1).

Figure 3-1: Flow diagram of the study selection process



3.5.2 Study characteristics

All 25 included articles were published in English; no relevant studies published in Arabic were identified. All studies employed a cross-sectional design except for one, which was a case-control study.²⁸⁰ Across the five levels of the SEM, only behavioural, socio-economic and

environmental factors were assessed by included studies. Most included studies ($N= 18$) examined individual risk factors exclusively or with other interpersonal or environmental factors,²⁷⁹⁻²⁹⁶ but no studies examined community and policy factors. In addition, 13 studies included both genders,^{279-282,285,290,292,295-300} seven included only males^{283,284,287,288,293,294,301} and four included only females.^{286,291,302,303} One study did not specify the participants' gender(s).²⁸⁹ Although a Saudi growth reference was created in 2005,³⁰⁴ none of the studies used country-specific growth charts. The CDC's age- and sex-specific growth chart was most commonly used (in eight articles),^{279,282,286,288,290,296,301,303} followed by WHO 2007^{295,297,298} and IOTF^{280,291,294} (3 articles for each reference) and WHO 2000^{285,292} and WHO-NCHS^{281,300} (two articles for each reference). Six studies did not specify which reference was used as a standard.^{283,284,287,289,293,299} All studies used self-report measures to assess risk factors except three.²⁸⁴⁻²⁸⁶ Appendix 2 summarises included studies, their quality score and SEM levels addressed.

3.5.3 Quality assessment

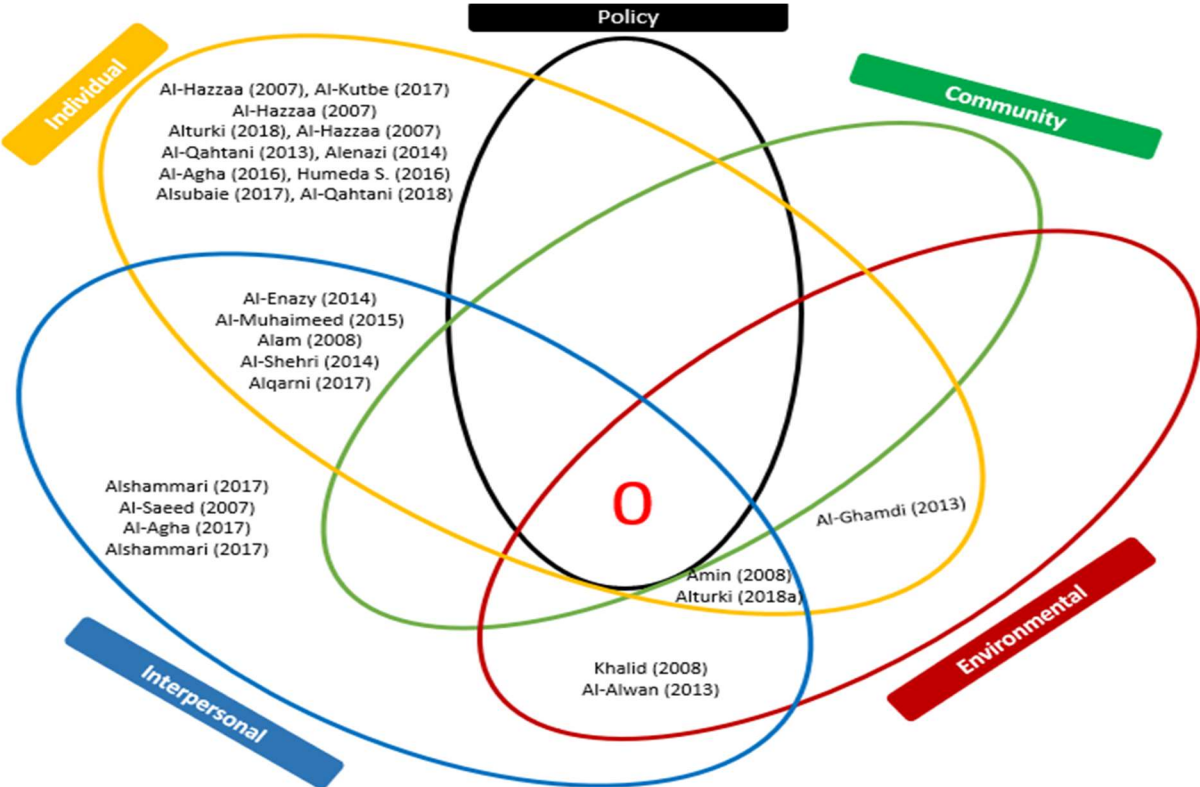
36% (nine studies) met $\geq 80\%$ of the AXIS criteria,^{280,284,286,290,292,294-296,299} 56% (14 studies) met 60–70% of the AXIS criteria^{279,283,285,287-289,291,293,297,298,300-303} and two met $\leq 60\%$ of the AXIS criteria (Appendix 3).^{281,282} All studies described their objective, study design, target population and basic data. However, statistical analyses were poorly conducted and/or reported in all studies. No studies adjusted for confounding factors or reported adjustments of confounding factors. Moreover, some studies only reported the P-value and neglected to report and interpret the confidence interval (95% CI) for identified associations. In addition, 12 studies failed to justify their sample size,^{279,281-283,287-289,297-299,302,303} 15 studies did not report their response rate,^{279-284,287-289,293,297,298,301-303} and 19 studies did not mention the validity of instruments used to assess risk factors.^{279-283,286-289,291-293,295,297-299,301-303} Furthermore, five studies did not specify

whether the participants' consent was obtained,^{281,287,288,299,302} and nine did not mention whether there were any funding sources or conflicts of interest.^{284,285,288,291,294,298,300-302}

3.5.4 Mapping findings onto the Socioecological Model

The SEM proposed by the CDC was used in this review: 1) all factors intrinsically connected to the child, e.g., personal behaviours and beliefs (individual level); 2) peers', parents' and close relatives' characteristics (interpersonal level); 3) religious groups, social associations, or others that incorporate the child (community level); 4) built and social environment features, such as urban design and neighbourhood SES (environment level); and 5) broader factors, such as policies and legislation (policy level).^{305,306} Figure 3-2 below shows the relationships between and among all articles considered in the review, including how they overlap in different levels of the SEM. The intersections in this diagram were illustrated as 'AND' areas, meaning that a study could only be in an intersection area if it examined risk factors crossing multiple levels of the model.

Figure 3-2: Venn diagram mapping the included studies.



The '0' in the centre of this diagram indicates that no studies have jointly examined all five SEM levels. In addition, policy- (black area) and community- (green area) level risk factors have not been examined in those studies. Previous research has been predominantly focused on personal-level risk factors (such as PA levels, TV duration, sleep, and eating behaviours). Eleven studies examined risk factors at the individual level exclusively (yellow area), and five studies examined risk factors at both the individual (yellow area) and interpersonal (blue area, such as SES) levels. In addition, two studies examined individual (yellow area), interpersonal (blue area) and environmental risk factors (red area, such as home space for PA, No. of TV at home, residence and availability of food), while four studies examined interpersonal risk factors exclusively (blue area).

3.5.5 Association of behavioural, environmental, and socio-economic risk factors

3.5.5.1 Physical activity

The association between childhood overweight/obesity and PA, including sports, outdoor activities and walking, was assessed in 11 studies,^{279,281,282,284-288,291,292,301} of which nine studies used self-report measures,^{279,281,282,287-292} and only three studies used objective measures (pedometer).²⁸⁴⁻²⁸⁶ Some studies that used self-report defined PA as sedentary, moderate, or high activity,^{279,281} while other studies defined PA as sports engagement and/or frequency/duration of exercise.^{282,288,291,292,301} In addition, one study did not state how PA was defined.²⁸⁸ Most studies that used self-report were poorly reported, and did not provide information about the validity and reliability of the PA measure itself.

Al-Kutbe et al., who investigated daily PA among girls aged 8-11 years, found no significant differences in minutes spent in the moderate and vigorous intensity of PA among BMI groups. The overweight group recorded the lowest average minutes per day in vigorous activity (1.5 mins/d). The obese group spent the highest percentage of time in sedentary activity (466.44 ± 156.90), but this difference was not statistically significant compared to the other group. Average daily steps were similar across BMI categories, and the group mean value was 6,757 steps per day.²⁸⁶ Furthermore, Al-Hazzaa examined PA levels among obese and non-obese boys aged 8-12 years. He found that based on BMI, the obese group's mean step counts (10,602±4,800 steps/day) were significantly (P=0.004) less than the normal group (14,271± 5,576 steps/day). Based on fat percentage, the obese group took significantly (P=0.009) lower steps per day (12,682± 5,236) than the non-obese boys (14,915± 5,643).²⁸⁴

Engagement in sports and exercise duration were reported to have a significant role in reducing the risk of obesity among children (3-18 years).^{279,281,282,287,291,301} Children who did not engage in sport were found to be 50% more likely to be overweight than those who engaged in sport

≥ 2 hours/day (OR=0.54, 95% CI 0.25–1.20, P=0.002).²⁹² However, the authors did not specify which type of sport was beneficial and protective against childhood obesity. Moreover, a significant negative association was found between the duration of exercise and BMI (P = 0.015, r = -0.147) among children aged 3-18 years.²⁹⁸ In addition, the type of sports (football) and BMI (P = 0.02) were negatively associated only among boys aged 3-18 years.³⁰¹ Furthermore, no statistically significant association was found between BMI and daily walking.^{285,286,288,292} The association between PA environments and childhood obesity was examined only in one study,²⁹⁶ reporting that lack of space at home for PA was negatively associated with obesity among boys (OR=1.89, 95% CI 1.19–3, P=0.006) and girls (OR=1.61, 95% CI 1.10–2.35, P=0.014) aged 9 -12 years. Moreover, no significant associations among children aged 9-14 years were found between PA and obesity in different locations (outdoors; P = 0.626), (home; P = 0.905) or (school; P = 0.870).²⁸⁰

3.5.5.2 Screen time (ST)

The relationship between ST and childhood overweight/obesity was assessed in 10 studies with mixed findings.^{279-282,285,287,288,291,295,301} Five studies found a significant positive association.^{279,280,282,285,291} One study examined the association between obesity and TV viewing among children aged 9-14 years and found that having one TV at home was associated with a decreased risk of obesity compared to more than one television at home (OR = 0.58, P = 0.001). The study also found that the ownership of a TV by a child was linked to a higher risk of becoming obese (OR = 1.75, P = 0.002) and that the risk of obesity was reduced by 19% with every one-hour reduction in weekend TV viewing.²⁸⁰ However, no association was found between computer/internet use/video games and the risk of childhood overweight and obesity.^{280,287,288,295}

3.5.5.3 Eating behaviours

The association between childhood overweight/obesity and eating behaviours was assessed in 16 studies.^{279,280,282,283,286-294,296,301,302} Only one study focusing on boys aged 12–15 years³⁰¹ found no association. Seven studies assessed the associations of childhood obesity with the frequency of fast-food consumption and eating away from home. Two studies found no association.^{291,301} Amin et al. found that eating away from home increased the risk of being obese among boys aged 10–14 years who ate 1–2 times weekly from (OR=0.2, $p<0.001$) to (OR=4.1, $p<0.001$) among boys who ate >5 times/weekly.²⁹⁴ Al-Muhaimeed et al. found that eating in restaurants ≥ 2 times per week doubled the risk of childhood obesity (OR = 2.41, 95% CI 1.26 to 4.64, $P = 0.03$).²⁹² Alturki et al.'s findings confirmed this and added that this association was stronger in boys than in girls aged 9–11·99 years (OR = 0.25; 95 CI 0.16–0.37; $p<0.001$).²⁹⁰ Moreover, obesity risk was positively associated with larger junk food portion sizes (OR= 2.61; 95% CI 1.03 to 6.61; $P=0.038$). Specifically, choosing a larger portion of French fries (OR = 4.95; 95% CI 1.94 to 12.63; $P < 0.001$) or choosing a soft drink with a fast-food meal corresponded to an increase in childhood obesity risk.²⁹⁰

The association between breakfast and childhood overweight/obesity was assessed in six studies.^{283,292-294,296,302} El-Enazy found that irregular breakfast consumption was associated with abnormal BMIs (over and underweight) among male children (OR = 0.02, $P < 0.001$).²⁸³ The place where breakfast was usually eaten (home or school) was also significantly associated with childhood obesity in two studies.^{294,296} A negative relationship was found between the risk of childhood obesity and having breakfast at home (OR = 0.77, 95% CI 0.60 to 0.99, $P = 0.049$).²⁹⁶ This finding was also supported by Amin et al. who found that eating breakfast at home was significantly associated with a reduced risk of being obese in boys aged 10-14 years (OR=0.54, 95% CI 0.33–0.89, $P=0.01$).²⁹⁴ In contrast, two studies found no association between childhood overweight/obesity and having breakfast at home or elsewhere.^{292,302}

Three studies assessed the association between eating at school (breakfast, lunch, snacks or a mixture) and childhood overweight/obesity.^{293,296,302} While two studies found no association between eating food at school and the risk of obesity,^{293,302} one study found that consumption or provision of fried potatoes ($P = 0.01$) and chocolate ($P = 0.03$) was positively associated with the prevalence percentage of overweight/obesity among children aged 6–12 years.²⁹³ Moreover, eating at school canteens was positively associated with an increased risk of obesity in this study (OR = 0.74, 95% CI 0.55 to 0.99, $P = 0.42$).²⁹⁶

The association between consumption frequency of less healthy snacks and/or soft/energy drinks and childhood overweight/obesity was assessed in eight studies,^{280,286,288,289,291,296,301,302} with three identifying a statistically significant relationship. A case-control study of 9-14 years old children found a positive association between the daily consumption frequency of snacks and the risk of obesity ($P = 0.005$).²⁸⁰ In a different study, the constant availability of snacks (OR = 0.71, 95% CI 0.55 to 0.92, $P < 0.0001$) and soft drinks (OR = 0.32, 95% CI 0.22 to 0.48, $P < 0.0001$ at home, and eating snacks before sleep were positively associated with the risk of obesity ($P = 0.000$).²⁹⁶

Three studies examined the association between eating while watching TV and obesity,^{280,282,296} but only one study in 2-18 years old children,²⁹⁶ found a positive association in boys only.

Several studies examined fruit and/or vegetable consumption,^{288,293,301,302} the number of meals eaten per day,^{280,288,292,302} and water or milk consumption,³⁰² but no evidence was found that these factors were associated with the risk of childhood overweight/obesity.

3.5.5.4 Sleep

Two studies assessed sleep duration,^{295,301} but no evidence of association was found between this factor and the risk of childhood overweight/obesity.

3.5.5.5 Maternal education and occupation

The association between a mother's educational attainment and the risk of childhood overweight/obesity was assessed in nine studies.^{279,292-294,297,298,300,301,303} While two of the studies found the risk of obesity among children increased positively with their mother's education level,^{297,303} one study found maternal educational level was negatively associated with obesity in boys.²⁹⁴ The children of mothers with university degrees were found to have a three-fold higher risk of being overweight or obese (OR = 3.7, P < 0.01 with 95% CI 1.62 to 8.48) compared to those with less-educated mothers.²⁹⁷ This finding was supported by Al-Saeed et al., who found that the prevalence of obesity was higher among girls with highly educated mothers.³⁰³ However, Amin et al. found the reverse, that low maternal educational level was associated with obesity among male children (OR = 1.5, 95% CI 1.1 to 2.1, P < 0.05).²⁹⁴

Seven studies assessed the association between a mother's occupation and childhood obesity,^{279,291,292,294,295,298,303} but only three studies reported a statistically significant association.^{294,295,303} In two studies, children with working mothers were more likely to develop obesity than those with unemployed mothers.^{294,295} However, one study found that children of unemployed mothers were more likely to develop overweight and obesity than children of employed mothers.²⁷⁹

3.5.5.6 Paternal education and occupation

Nine studies assessed the association between paternal educational level and childhood overweight/obesity risk,^{279,293-298,300,301} but only four reported a statistically significant association.^{294-296,301} Children with overweight and obesity were likely to have highly educated fathers.^{295,301} However, Alturki et al. found that having a father with an advanced education was

associated with reduced obesity only among male children (OR = 1.97, 95% CI 1.2 to 3.2, P = 0.004).²⁹⁶

The association between paternal occupation and childhood overweight/obesity was assessed in five studies.^{279,294,295,298,303} Two studies reported that children affected by overweight or obesity were more likely to have a working father than children of unemployed fathers.^{279,294} One study found that such a relationship only existed in girls whose fathers worked in the private sector.³⁰³

3.5.5.7 Family income

Seven studies assessed the association between family income and risk of childhood overweight/obesity,^{279,292,296-298,300,303} but only five found a statistically significant association with mixed results.^{279,296-298,300} Children affected by obesity and overweight were more likely to come from high-income families than children of low-mid-income families (aOR = 3.2 95% CI 1.6 to 2.6, P < 0.0001).³⁰⁰ Similarly, Al Alwan et al. found that children of high-income families (> 20000 SR/month) are at higher risk for being overweight (OR = 3.38, P < 0.01, 95% CI 1.90 to 6.02) compared to other groups.²⁹⁷ However, Alturki et al. found that obesity was more likely among low (OR = 1.58 95% CI 1.14 to 2.19) to mid (OR = 1.43 95% CI 1.05 to 1.95) income families.²⁹⁶

3.5.5.8 Family size

Three studies examined the association between family size and childhood overweight/obesity risk.²⁹³⁻²⁹⁵ Of these, two reported a significant association between the two factors.^{294,295} Those two studies reported a significant positive association between a small family size (≤ 6) and childhood obesity in SA.

3.5.5.9 Residence

The association between place of residence and the risk of childhood overweight/obesity was examined in three studies,^{294,300,301} of which two found a statistically significant association.^{294,300} Children residing in urban areas were more likely to develop overweight or obesity than children living in rural areas.²⁹⁴ In addition, children born and living at high altitudes were at an increased risk of obesity and overweight compared to those born and living in low altitudes (aOR = 1.8, 95% CI 1.3 to 2.6, P < 0.001).³⁰⁰

3.6 Discussion

3.6.1 Key findings summary

This review included 25 studies that examined associations between modifiable risk factors and overweight/obesity among children aged 2–18 years in SA. There was inconsistent evidence on some risk factors, including PA, ST and eating behaviours, and conflicting evidence was found for SES. Another key finding includes a lack of research on community- and policy-level risk factors of childhood obesity in SA. In addition, major methodological flaws were identified in the included studies and described in more detail in section 3.6.3 below.

3.6.2 Findings in relation to the literature

The present review found inconsistent evidence on the association between PA and obesity among children aged 2-18 years in SA. This finding is similar to the previous review of the MECs that involved children and young adults (> 20 years).²⁷⁴ However, an international review of 18 longitudinal studies involving children and adolescents aged 10-19 years found that PA has some protective effects against overweight/obesity.³⁰⁷ Likewise, an international review of longitudinal studies examining factors that predict obesity development among children aged 5-18 years found sufficient evidence to demonstrate the inverse association between excessive fatness and objectively measured PA.³⁰⁸ The type of eligible study design in

those international reviews was a longitudinal design,^{307,308} which is lacking in SA. This may be a potential reason why findings regarding PA differ from those of international reviews. Moreover, there is an over-reliance on self-reporting and unvalidated tools, combined with an imprecise in defining PA across most included studies. Future research is recommended to use a longitudinal design to establish causation, a precise definition of PA, and validated and objective measures of PA to advance our knowledge of this topic.

Regarding eating behaviours, inconsistent findings were found. This finding is similar to the previous review of MECs.²⁷⁴ Moreover, two international reviews of longitudinal studies among children aged 5-18 years and 10-19 years found inconsistent results regarding the association between eating behaviours and overweight/obesity.^{98,308} However, a recent systematic review examining the correlation between dietary factors and obesity among children aged 6–12 years in MECs found that dietary behaviours (such as skipping breakfast, refined carbohydrate intake and excessive fat intake) were associated with the risk of childhood obesity.²⁷⁵ However, the review only included four cross-sectional studies (rated as good quality), one of which was from SA. The inconsistency of findings in the current review could be partially attributed to the variety of assessment tools employed to assess eating behaviours in conjunction with the self-reporting and unvalidated tools used by most studies. An inaccurate dietary assessment could act as a barrier to understanding the effect of eating behaviours on obesity development among children. Therefore, continual efforts should be undertaken to improve or develop tools for dietary assessment.^{309,310}

ST, in general, is defined as the amount of time spent using or viewing anything with a screen, including TVs, mobiles, tablets, PCs, laptops and video games.³¹¹ The current review found inconsistent findings regarding the association between ST and the risk of obesity among children in SA. Similarly, a systematic review of 29 reviews in children (> 19 years) found that

assertions of a causal link between obesity and ST are misguided or premature, and there is little to no evidence for causality.³¹² However, a recent review and meta-analysis of 16 studies examining the relationship between ST and overweight/obesity in children (<18 years) reported that computer time, total ST and TV time were correlated positively with childhood overweight/obesity.³¹³ However, it is essential to note that all studies included in this review used self-reporting,³¹³ which is subject to social desirability bias. Moreover, the review did not include studies examining the association between the use of digital devices (such as tablets and smartphones) and childhood overweight/obesity,³¹³ which have become increasingly popular among the child population. In the current review, most studies only examined the association between childhood overweight/obesity and one kind of ST (mainly TV). This is unlikely to reveal the overall effect of ST on overweight or obesity among children. Future studies on this topic should therefore include various types of screens to assess the influence of ST on childhood overweight/obesity, aligning with using the emerging research tool of ‘wearable cameras’ that might be helpful for objectively measuring children’s ST in future studies.

Regarding sleep, the present review found only two studies examining the relationship between sleep duration and childhood overweight/obesity. Both studies used self-reporting measures, and no evidence of an association was reported. However, three international systematic reviews and meta-analysis examining the longitudinal associations between sleep duration and childhood overweight/obesity found a positive association between short sleep duration and obesity among children aged > 18 years.³¹⁴⁻³¹⁶ Collectively, there is consistent evidence of positive associations between short sleep and obesity among children. Future studies using objective measurement (sleep actigraphy), preferably in a longitudinal design, and considering potential confounding factors, are needed in SA.

SES may influence people's living environments, including, for example, their access to healthy food and PA opportunities. This, in turn, can affect people's energy intake and expenditure.³¹⁷ In the present review, 12 studies assessed the relationship between SES and childhood obesity, yet their findings were inconsistent. Findings on SES are similar to a recent international review of 40 cohort studies in children and adolescents aged 10-19 years that found inconsistency across studies assessing the association between SES and obesity.⁹⁷ However, reviews of developed countries have shown a strong inverse association between low SES and childhood overweight/obesity.^{153,318}

Conversely, a systematic review of developing countries found a positive association between affluent children and obesity.¹⁵⁰ These differences between developed and developing countries in terms of the association between SES and childhood obesity might be explained by the fact that the association of SES with the risk of childhood obesity varies by gender, age and country.^{317,319} The current review included studies from various geographic regions in SA with different age and gender groups and SES indicators/classification methods. These reasons may explain why conflicting evidence was found for SES. This review suggests that to make a confident conclusion about the relationship between SES and the risk of obesity among children in SA, a nationally representative sample and carefully chosen SES measure(s) should be used.

Mapping findings onto the SEM model reveals a lack of research on community- and political-level risk factors of childhood obesity in SA. This mapping exercise also reveals insufficient studies (N=6) that have examined the association between environmental variables and childhood obesity. The majority of included studies examined individual/behavioural factors. Therefore, more studies are needed to advance our understanding of what and how community, political and environmental factors are associated with the risk of childhood obesity in SA. This reinforces the need to adopt the systems-based approach to understand and tackle public health

issues like childhood obesity. Such an approach requires investigation of not only *what* factors may contribute to the development or prevention of childhood obesity but also *how* these factors may *change and interact* with each other over time as a dynamic system(s). This mapping exercise found that most studies predominantly examined individual factors, although the complex nature of obesity has been well illustrated in the Foresight system map in 2007.³²⁰ This misplaced focus on individual-level factors carries a risk of implementing traditional interventions that have minimal reach and effect across populations. A shift from reductionist, linear, single-perspective thinking to holistic, non-linear systems thinking is required to understand and tackle obesity.² This shifting will provide policymakers with robust and relevant evidence that can help design effective and sustainable systems-based interventions. Therefore, using systems science tools may be ideal for capturing a complete picture of childhood obesity determinants and integrating them into addressing childhood obesity within the country. However, it is worth noting that the effectiveness of systems-based interventions to tackle obesity is still in its infancy, but its promising role in identifying causes and mechanisms of childhood obesity is documented in the literature.^{237,321}

3.6.3 Methodological issues

This review identified some common methodological limitations in the included studies, which should be considered when interpreting the review's findings. First, all studies except one employed cross-sectional designs, which, in turn, precluded the ability to determine causality. Second, most studies failed to report whether a validated instrument had been used to assess participants' exposure to a risk factor, making it difficult to assess the validity of their findings. Third, 18 of the 25 studies only reported and relied on the P-value to determine the presence or absence of an association. In addition, any P-value reported in the result section without other values, such as confidence interval, demonstrates that other values are missing in the included

articles. In addition, relying only on P-value to determine the association is problematic.³²² A statistically significant difference may be inferred from a relatively small P-value. However, this does not always guarantee that the distinction will be helpful or even important in clinical contexts. Establishing whether the difference is sufficiently significant for practical significance is necessary. Having a relatively big difference would serve a practical purpose. On the other hand, a slight difference may not even be worth the time, effort, or money for such a minor influence. This creates complications when attempting to draw conclusions from the data and understand the findings.³²² Moreover, all studies failed to report whether any confounding factors were adjusted for in data analysis. Finally, there is still no improvement in more recent studies when there is a better opportunity for more precise exposure measures using device-based data.

3.6.4 Strengths and limitations

This is the first systematic review of modifiable risk factors of obesity among children aged 2-18 years in SA using the SEM. This review's main strength is that it included only studies that used objective measures of height and weight, as self-reporting of anthropometric measures may lead to misclassifications in child weight status.³²³ The use of BMI, waist circumference, body fat percentage and skinfolds as outcome measures constitutes an additional strength, as it is ensured that the disadvantages of using BMI, such as not measuring body fat or distinguishing between fat mass and lean mass, were excluded. Furthermore, using the SEM framework to map out previous research is novel and innovative, making this review's findings more usable in identifying under-researched themes of risk factors and intervention strategies. Nevertheless, the review also has several limitations. The conclusion of this review is limited by the number and types of studies included, which were generally poorly conducted and reported. A further limitation of this review is related to the age of the population, which combines children and

adolescents studies together. However, based on the scoping search of the Saudi literature before conducting this review, I found that most Saudi studies on childhood obesity consider a child as anyone under 18 years, and most Saudi studies involved participants between 2 to 18 years in examining risk factors associated with childhood obesity. Readers should be cautious interpreting findings as the age of the population in the included studies can be considered as children and adolescents age (2-18 years).

Moreover, although Arabic databases were searched, no studies were found. This might be because most Saudi universities count only research studies published in English for faculty promotions, especially in the medical and scientific fields. Therefore, most faculty members choose to publish in English. This review may be prone to publication bias as no grey literature was included. It may be that the results of grey literature differ from those presented in the included studies. Finally, a meta-analysis could not be done due to the heterogeneity of the included studies.

Overall, these variations severely limited the ability of this review to draw meaningful conclusions. Nevertheless, although obvious weaknesses are apparent in relying solely on evidence from a weak study design, the large coverage of different literature regarding modifiable risk factors and childhood obesity and bringing together disparate findings into an evidence synthesis has much to commend.

3.7 Conclusion

The associations between most modifiable risk factors and the risk of obesity among 2-18 years old children in SA remain unclear due to inconsistent findings as well as the limited number, types (primarily cross-sectional) and quality of the included studies. Inconsistent evidence was found on the associations between PA, ST and eating behaviours and the risk of obesity.

Conflicting evidence was found for SES and the risk of obesity. Conclusions could not be drawn for other factors examined due to the limited number of studies identified. Importantly, there is a lack of research on the roles that community and policy-level factors play in childhood overweight/obesity, as well as limited research on environmental determinants. In light of the increased calls for a system-based approach to obesity interventions, this review reinforces the critical need for a holistic perspective on obesity etiological research in SA using a high-quality study design. This is fundamental to developing evidence-based, effective interventions to prevent childhood obesity in SA.

3.8 Chapter summary and contribution to the thesis

This chapter highlighted the modifiable risk factors associated with obesity among children aged 2-18 in SA. However, associations remain unclear due to inconsistent findings as well as the limited number, types (primarily cross-sectional) and quality of the included studies. In addition, mapping findings onto the SEM indicated a lack of research on the roles that community and political factors play in childhood overweight/obesity, as well as limited research on environmental determinants. Finally, this chapter indicated the need for a holistic perspective on obesity etiological research in SA using a high-quality study design.

This review has not been instrumental in informing the design of other studies in this thesis. However, this review contributed to achieving the main aim of this thesis - to assess the feasibility of applying CBSA to develop childhood obesity prevention interventions within the Saudi community. Specifically, the review helped identify several limitations, such as the type and quality of evidence within the Saudi childhood obesity prevention research. A further limitation is the lack of research examining the association of community, political and broader environmental factors with obesity among Saudi children. These limitations could have an impact on policymakers, thereby changing the direction in which policies are developed.³²⁴

Findings of this review were valuable when integrated with findings from other studies within this PhD project to determine the feasibility of CBSA. Chapter 8 provides more details regarding how the current Saudi evidence base about childhood obesity could influence the feasibility of using CBSA to develop childhood obesity prevention interventions. The next chapter presents a scoping review of the comprehensive application of the systems approach to obesity prevention.

Chapter 4: The comprehensive application of systems approach to obesity prevention: a Scoping Review of Empirical Evidence

4.1 Chapter overview

This chapter reports the findings of a scoping review conducted to identify and synthesise programmes/studies that have comprehensively used the systems approach for obesity prevention. This study addressed the second objective of this thesis: *What has been achieved to date in terms of applying a comprehensive systems approach to obesity prevention?* Findings are expected to eliminate any ambiguities regarding what the systems approach entails in practice. This review found that only five publications (three studies) met inclusion criteria, which might be explained partially by suboptimal reporting. No conclusion on the effectiveness of this approach can be drawn yet due to the extremely limited evidence base. In addition, this review identified common features shared by the included studies, and facilitators and barriers to applying a comprehensive systems approach in practice. A part of this chapter (Table 4-2) was recently published in a peer-reviewed journal.³²⁵

4.2 Introduction

The literature review chapter (section 2.9.3) has shown the advocacy of using tools from systems science as potential tools to address the complexity of obesity. In addition, it was highlighted that despite the concepts and terminology of systems approach existing for several decades in other sciences,^{326,327} empirical knowledge about their application and effectiveness for obesity prevention is limited. Therefore, more clarity is required regarding what systems-based obesity prevention interventions look like in practice.

Multiple approaches exist to understand and address complexity within traditions of systems thinking, meaning systems approach to tackling obesity could therefore take different forms.³²⁸

Common approaches stem from system dynamics that seek to surface and use mental models of cause and effect within specific problems and identify relationships of feedback and the impacts of change over time within this system. Despite its underpinning theoretical tradition, any adoption of a comprehensive systems approach for obesity intervention should be informed by a clearly defined branch of systems sciences. Approaches should recognise nonlinear and dynamic interactions between variables operating across different levels or subsystems within the environment where a target population lives. The process of, or approach to, intervention development, implementation and evaluation must actively engage with this complexity both across and within intervention components/settings. This means that an intervention which solely comprises multiple components and/or operates in multiple settings is not necessarily an intervention taking a systems approach.^{250,329,330}

However, previous programmes/studies often used the term "whole system approach" (WSA) to refer to the term "systems approach", although the differences between these terms are distinguishable. A WSA has been included in a long list of approaches applying multi-level, multi-agency, cross-disciplinary community interventions to tackle health issues influenced by complex socio-economic conditions.³²⁹ A comprehensive systems approach recognises and utilises mental models, feedback loops and structures within a system; and may re-orient the goals, structures, and resources of the system.^{250,330}

Several reviews have used the term "WSA" to identify obesity prevention programmes. In 2010-2011, three reviews were planned to inform the development of the National Institute for Health and Care Excellence (NICE) guidelines on using WSA for obesity prevention.^{329,331,332} The purposes of those reviews were to identify the key elements of WSA, the effectiveness of WSA and barriers/facilitators of WSA to obesity prevention. However, the definition of the systems approach described above is different from the definition used in previous reviews.

The NICE reviews defined WSA as depending on the science of complexity. They did not identify any programme/study that applied a comprehensive systems approach, so they widened the definition of WSA to include multi-level/multi-setting programmes. The NICE reviews proposed a list of ten characteristics of a WSA to address obesity based on their wider definition. A later systematic review was conducted by Bagnall et al. to synthesise available evidence on WSA targeting obesity. The review was based on the NICE ten proposed WSA features.³³³ Since these features were based on studies that did not use the SAP, Bagnall et al., continued to overlook more traditional components of systems science. Bagnall et al., also found little application of systemic work and identified the need to redefine WSA in relation to obesity. Furthermore, previous reviews did not consider all stages of interventions, including design, implementation and evaluation.

The 2019 Public Health England guide to support local approaches to promoting a healthy weight using a WSA offered a better description of WSA.³³⁴ Although some of the case studies included in this guidance might not show evidence of taking the SAP in all intervention stages, the definition and guidance offered in this document recognise essential features of systems thinking. Thus, they are helpful to the academic community, public health practitioners and policymakers in a practical sense. Recently, a systematic review identified different systems methods used to evaluate public health interventions. However, this review included studies self-identified as applying the systems approach.³³⁵ Given existing confusion regarding the meaning of the systems approach, some studies included in this review might not have applied a comprehensive systems approach.

Foster-Fishman's framework clarifies what the systems approach to intervention development might entail. The framework describes the systems approach as comprising 'bounding the system', 'understanding system elements', 'assessing system interactions', and 'identifying levers

for change'.^{1,336,337} As a result, this review used Foster-Fishman's framework as a part of the criteria during the study selection process.

To date, no systematic review has exclusively focused on programmes/studies that have applied an authentic systems approach to obesity prevention, as defined based on the latest academic knowledge. Therefore, a systematic scoping review is needed to identify and synthesise programmes/studies that comprehensively use a systems approach for obesity prevention.

4.3 Methods

A scoping review is a suitable method to explore research fields that have recently emerged,^{338,339} such as applying the systems approach to obesity prevention. This review adopted the five stages framework provided by Arksey and O'Malley³⁴⁰ and developed further by Levac et al.³⁴¹ In addition, this review used the reporting criteria of The PRISMA Extension for Scoping Reviews (PRISMA-ScR).³⁴²

4.3.1 Identifying the research question

This review aimed to identify and synthesise programmes/studies that have comprehensively used the systems approach for obesity prevention. Arksey and O'Malley advocate broadening the research questions,³⁴⁰ but clearly defining the outcome of interests was required to keep the review focused.³⁴¹ The main research question was, "*What has been achieved to date in terms of applying a comprehensive systems approach to obesity prevention?*" The sub-questions were as follows:

- a) How many studies or intervention programmes have made a comprehensive application of the systems approach to obesity prevention as defined in this review?
- b) What is the available empirical evidence on the effectiveness of this intervention approach?

- c) Were there any adaptations incorporated into the systems approach to obesity prevention to suit different settings?
- d) What were the main features shared by studies/programmes that made a comprehensive application of the systems approach to obesity prevention?
- e) What are the reported facilitators and barriers to applying this systems approach to obesity prevention?

4.3.2 Identifying relevant studies

As recommended by Arksey and O'Malley³⁴⁰, this review adopted a broad search strategy and considered a wide range of sources. Due to the initial stages of research in applying the systems approach to obesity prevention, this level of scope was thought viable. The following sections report studies identification.

4.3.2.1 Identify relevant outcomes

For research question 2, studies should have reported at least behavioural or anthropometric outcomes. In addition, other outcomes were included, such as intervention implementation, cost-effectiveness, and psychosocial impact, to capture all available empirical evidence.

4.3.2.2 Type of sources

Any peer-reviewed research was considered. Grey literature was also considered (e.g., government reports) because it might be possible that some programmes are described in government (and their agencies) reports which may provide valuable data for this review. However, it was not considered to include theoretical literature, editorials, opinion pieces/commentaries and conference abstracts. In addition, any studies that used systems science to understand the mechanisms of obesity were excluded unless they aimed to inform the development of a systems-based intervention and the intervention has been

implemented/evaluated. To be considered a comprehensive application of the systems approach, studies/programmes needed to meet all the following criteria associated with the development, delivery/implementation, and monitoring/evaluation stages of an intervention's life cycle:

- a) The process of developing the intervention featured all the principle steps for transformative systems change provided Foster-Fishman's framework³³⁶ (Table 4-1), AND
- b) The chosen approach to deliver (for experimental purpose) or implement (as a public health initiative) the intervention showed evidence of recognising the dynamic and complex nature of the intervention and the system for which the intervention was developed, AND
- c) The chosen approach to monitor/evaluate the developed intervention also showed evidence of recognising the dynamic and complex nature of the intervention and the system for which the intervention was developed.

Table 4-1: Foster-Fishman framework (source: Bellew, B; 2020)

Bounding the system	Understanding system parts	Assessing system interactions	Identifying levers for change
<ul style="list-style-type: none"> • Defining the issue and identifying key levels, players, and institutions. 	<ul style="list-style-type: none"> • Understanding all systems parts such as operations, regulations, resources and norms. 	<ul style="list-style-type: none"> • Assessing all interactions- balancing and reinforcing, feedback and delays 	<p>Finding parts to leverage for change:</p> <ul style="list-style-type: none"> • Having or having the potential to have effects on several levels and feasible to change. <p>Finding interactions/patterns to leverage for change:</p> <ul style="list-style-type: none"> • Distinctions within systems that provide niches conducive to the aims of system transformation. • Long-term patterns that help or hurt efforts to effect change • Voids in the mechanisms of system feedback. • Connections between levels and sectors that are required.

4.3.2.3 Type of participants

No restrictions were applied on research/community settings or participants' characteristics (e.g., country, age, sex, and ethnicity). All population or community groups were eligible.

4.3.2.4 Search strategy

Several databases were searched from inception to February 2021, including Web of Science, PubMed, and MEDLINE. Moreover, grey literature was also searched with particular attention to major bodies, including: The Australian Prevention Partnership Centre (TAPPC), the Department of Health (in AUS&UK), Sax Institute (AUS); NICE; and the Association for the Study of Obesity (ASO). Google Scholar was also searched (first ten pages) using combination terms. Relevant reviews were hand-searched for relevant articles. A list of search terms used during the search is provided in Appendix 4.

4.3.3 Study selection

All references were imported into Covidence online software.³⁴³ This software was selected because it facilitates screening and supports dual reviewers. Duplicate references were removed using the online software. Manual hand screening was also conducted to ensure that de-duplication was done correctly. Two reviewers independently screened the titles and abstracts and selected articles based on the predetermined criteria (described in *Stage 2. Identifying relevant studies*).

4.3.4 Charting the data

Relevant data were extracted and recorded using a customised form piloted on a sample of the included articles and improved accordingly. The extracted data were on the author(s), year and type of publication, location/setting, targeted participants or population group, study aims,

systems methods/tools, intervention details, study design, outcome measures, and key findings from each programme/study.

Quality assessment

Although a critical appraisal of the evidence is not required for scoping reviews,³⁴⁴ the current review attempted to assess included intervention programmes or studies in terms of their methodological quality and reporting. The quality of studies that used a stepped wedge cluster randomised trial (SW-CRT) was assessed against The Consolidated Standards of Reporting Trials (CONSORT) extension abstracts (SW-CRT)³⁴⁵. This is a 17-item tool that assesses the quality of reporting of SW-CRT. Furthermore, the standard Critical Appraisal Skills Programme and EPPI-Centre (SCAS-EPPI) tool³⁴⁶ was also used to assess studies of process evaluations.

4.3.5 Collating, summarising, and reporting the results

This review is presented in two parts:

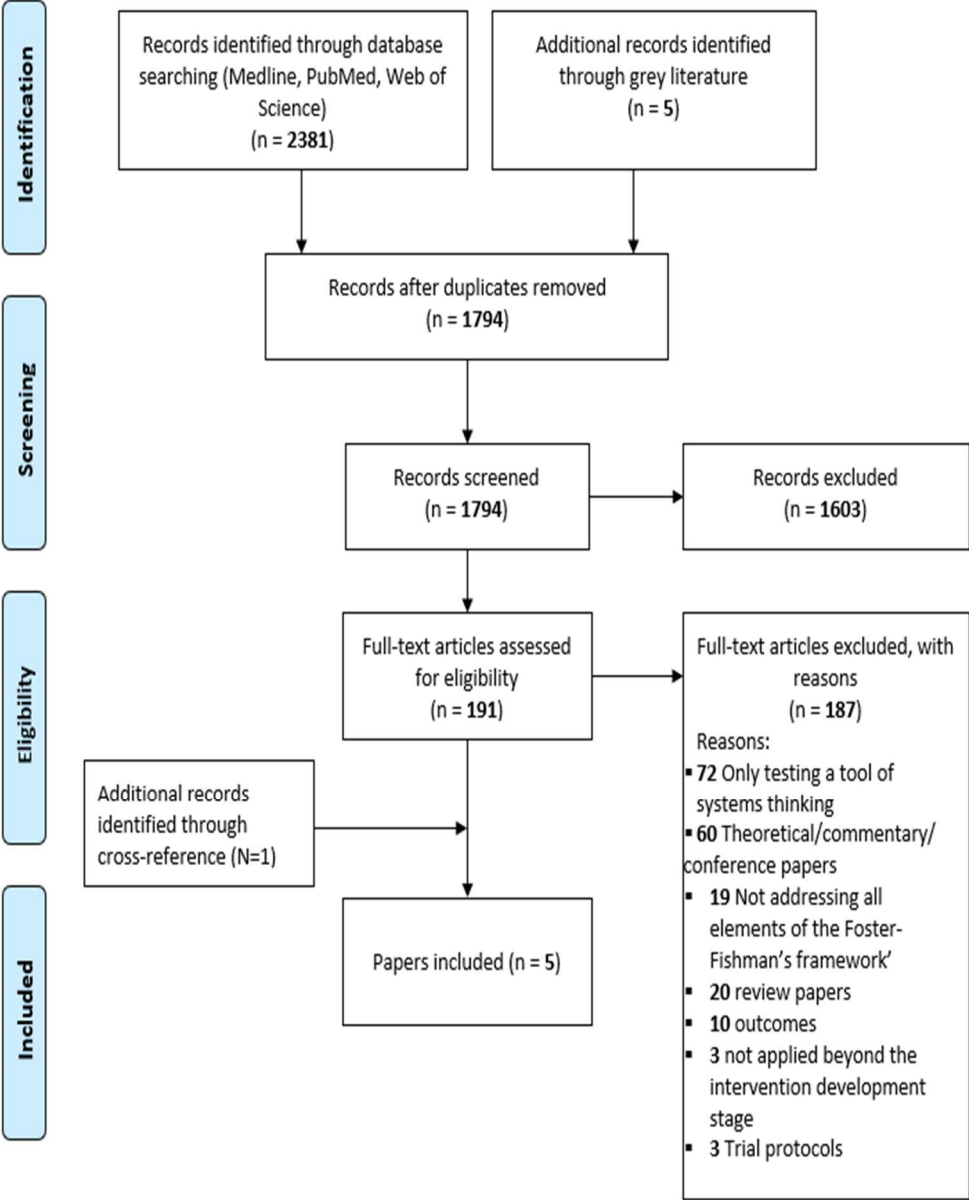
- 1) The descriptive analysis provides information on the included programmes/studies that have comprehensively used the systems approach to address obesity. A tabular form shows the programme name, location, systems science tools used, outcome examined and key findings (if any). For transparency, this review also provides a table that provides an overview of excluded studies which claimed to have used the systems approach.
- 2) A narrative summary that:
 - a) answers all formulated main- and sub-research questions
 - b) proposes a list of questions to assist future reporting of a comprehensive systemic obesity prevention work
 - c) provides recommendations for future research.

4.4 Results

4.4.1 Articles retrieved and characteristics

The search yielded 2,386 articles. After removing duplicates, 1,794 records underwent title and abstract screening, and 199 underwent full-text review (Figure 4-1). Of these, five articles met the inclusion criteria. The five articles were from two countries (one from the Netherlands and four from AUS) and were published between 2016 and 2020. Three articles describe the design and methods of three programmes for preventing childhood obesity.^{4,233,347} The remaining two articles report on a process evaluation and the key findings of one included an intervention programme.^{348,349} All included articles have been published in public health-related journals.

Figure 4-1: Flow diagram of scoping review study identification



4.4.2 Number of programmes/studies

This section details how many studies or intervention programmes have made a comprehensive application of the systems approach to obesity prevention according to the definition used in this review.

Three obesity prevention interventions met the inclusion criteria to apply the systems approach to obesity prevention (Appendix 5) comprehensively. Programmes that had self-identified as

having used the systems approach for obesity prevention were excluded. Excluded studies/programmes and reasons for exclusion are provided in Appendix 6. Most excluded programmes did not meet the intervention development stage criteria and did not address all elements of the Foster-Fishman framework.

4.4.2.1 The Whole of Systems Trial of Prevention Strategies for childhood obesity (WHOSTOP)²³³ and The Reflexive Evidence and Systems interventions to Prevent Obesity and Non-communicable Disease (RESPOND) study.³⁴⁷

These two studies were conducted in Victoria, AUS, using a similar methodological approach (systems dynamic) to intervention development, implementation, and evaluation. The WHOSTOP study (Western Victoria) predated RESPOND (Northern Victoria), the latter extended the approach pioneered in the earlier trial.

4.4.2.1.1 Intervention development

Both studies^{233,347} facilitated a deeper and shared understanding of system components such as systems norms, human resources, social resources, economic resources, operations, and regulations. This included examining the alignment of the present system with assumptions and values of desired result or change and assessing the extent to which the existing system entails or is constructing the infrastructure needed to achieve aims or the desired change.³³⁶

In the next step, both studies started to explore the interactions and interdependencies among system subsystems or components and how the system self-regulates using GMB workshops and co-produced CLD. These visualised the nonlinear and dynamic interactions between variables operating across different levels or subsystems within the environment. The CLD was used as a representation of the system at the third workshop with a broad group of community members to identify and prioritise levers that can be used to change the system.^{233,347}

4.4.2.1.2 Intervention implementation

Each intervention was oriented around strengthening leadership, workforce development, resources, partners, networks and intelligence through intensive training and support for each intervention community. The system intervention was carried out with community stakeholders who had authority or control over the environments in which children were exposed to the identified system drivers' risk factors. For WHOSTOP, the research team delivered the GMB workshops and was actively involved in planning implementation. In contrast, for RESPOND, the research team trained local community and health staff to deliver this process, plus a new and existing coalition of community leaders was convened to lead community-wide structural change.^{233,347} Both studies formed a steering group to prioritise changing systems to support PA, healthy eating options and prevent obesity among children throughout the intervention design phase.

4.4.2.1.3 Intervention evaluation

Both studies used a SW RCT,³⁴⁹ to minimise practical and ethical issues associated with complex, population-level interventions.

4.4.2.2 Lifestyle Innovations based youth's Knowledge and Experience (the LIKE programme)⁴

LIKE was a five-year study set in three districts in Amsterdam, with an intended overrepresentation of lower socio-economic and ethnic minority groups. It aimed to build a dynamic action programme based on the current system. It evaluated 1) how the system evolved in response to the developed programme and 2) how it contributed to improvements in health-related behaviours and the prevalence of overweight and obesity among children aged 10 to 14 years.

4.4.2.2.1 Intervention development

LIKE⁴ was started by understanding the pre-existing systems that contribute to determinants of dietary, PA, sleep and screen-based sedentary behaviours in the target population. Findings related to these determinants were summarised in a systems map built using GMB. This map served as a guide for developing actions and as a basis for evaluation. They used Social Network Analysis to identify the influential actors who play a crucial role within the local government and/or at the community level and invited them to develop actions through the use of GMB workshops.⁴

4.4.2.2.2 Intervention delivery and evaluation

The evaluation used developmental SAP, complemented with regularly obtained data on weight status and key health behavioural indicators.⁴ A key stated aspect of this approach was using the understanding gleaned in the systems maps to support adaptation, continuous development and feedback on systems change as the intervention programme was implemented. In other words, the intervention was being developed, implemented, monitored and re-developed in a continuous, adaptive process.⁴

4.4.3 Effectiveness of a systems approach

Only WHOSTOP paper³⁴⁹ reported the effectiveness of using a comprehensive systems approach for obesity prevention. No effectiveness findings had been reported for other included interventions at the time of writing.

WHOSTOP was evaluated using a SW-RCT design over four years and reported a significant decline in mean BMI z score in the intervention group within the first two years, followed by an increase. The mean BMI z score among the control group remained unchanged throughout the study period.³⁴⁹ A similar 'U shape' pattern of change was observed for the percentage of overweight/obesity in the intervention group, while the corresponding figure for the control

group remained stable. The authors suggested several contextual explanations for such findings. First, as planned, the research team focused less on implementation support during the second year for step-one communities in order to focus more on recruiting communities for step two. Due to natural disasters, control communities had to delay intervention uptake for two years. For the last two years of the research, the allocated resources were cut by at least half for the first group of intervention communities. Second, there might be an unintended consequence (e.g., complacency, a feeling of the job being done and shifting priorities) of seeing early indications of a favourable result in the intervention communities. The study failed to achieve the desired sample size (1,500 per trial arm) and was underpowered to detect hypothesised BMI z score change.³⁴⁹

4.4.4 Adaptations incorporated into the systems approach

No adaptations were reported for the included programmes. The WHOSTOP²³³, RESPOND³⁴⁷ and LIKE⁴ were each developed using GMB. In each case, these methods were underpinned by previously developed scripts to design and run these sessions. The scripts themselves provide scope for the design team to adapt the framing of the question, the scale of the target area and the systems requiring attention.

4.4.5 The main features shared by studies

The main features shared by all three included studies that have made a comprehensive application of the systems approach to obesity prevention?^{4,233,347} are described below.

4.4.5.1 Mapping the systems of obesity drivers and embedding actions within the systems

The WHOSTOP²³³, RESPOND³⁴⁷ and LIKE⁴ used a systems lens to understand the various system levels and interventions required for sustainable, large-scale changes. GMB workshops as a systems dynamic tool were used in all studies to create a system map that recognises nonlinear and dynamic interactions between variables operating across different levels or

subsystems within the target population's environment. All programmes 1) started with understanding current systems and contexts within the communities; 2) identified, prioritised, and acted on systemic drivers of obesity; and 3) identified ways in which current systems and resources can be re-oriented or used for better health outcomes. All three studies used the *Systems Thinking for Community Knowledge Exchange* (STICKE) software to support the process. STICKE was initially developed to support WHOSTOP³⁵⁰ and subsequently is continually adapted to meet the needs of the communities in terms of increasing understanding and aligning with their existing planning and reporting requirements.³⁵¹

4.4.5.2 Measuring ongoing changes, not just the endpoint outcomes

All studies^{4,233,347} demonstrated systems thinking throughout the development, implementation, and evaluation stages of their intervention's life cycle. Most notably, at the evaluation stage, all studies included evaluation and tracking changes in the systems.³⁵¹ Such an evaluation and monitoring approach is necessary, given the dynamic and adaptive nature of any system. For example, within the WHOSTOP study²³³, continuous data gathering and updates to the systems map helped optimise implementation and facilitate dissemination of the chosen actions; new ideas were stimulated in an adaptive, constructive, capacity-building cycle.

4.4.5.3 Measuring intervention processes

All studies undertook a process evaluation to understand how successfully the systems approach created a sustainable programme and how communities responded to systems interventions. Just as ongoing outcome measurements, process evaluation can also inform adaptive/new actions to optimise intervention outcomes. Both the knowledge about and interventions on the systems are advanced continuously. However, no authors reported whether or how process evaluation contributed to learning how the systems worked.

4.4.5.4 Local decision-makers and influential actors lead and own intervention development and implementation

A common feature across studies was that researchers in these studies supported local DMs and influential actors to develop and implement systemic interventions for transformative systems change through a co-creation, participatory approach.^{4,233,347} Those individuals were leaders from local government and other key sectors/subsystems of the communities. They have the authority, power, and/or resources to approve and/or implement prioritised interventions. In the WHOSTOP and RESPOND studies, community leaders who directly affected pre-adolescent environments were invited to develop and implement interventions. Social Network Analysis was used in LIKE to identify influential actors who were then invited to participate in all parts of the project.

4.4.5.5 Supporting capacity building as an essential goal alongside achieving clinical effectiveness

All included studies have explicitly spent effort strengthening the WHO system building blocks^{352,353}, including leadership, resources, partnership and intelligence in community settings. For example, the WHOSTOP study convened both established and new alliances of local leaders who have the ability and connection to drive community-wide systemic change. Moreover, the RESPOND study trained local community leaders to run GMB workshops. Furthermore, the LIKE study invited adolescents to a capacity-building workshop to teach them how to conduct research among their peers about healthy behaviours and possible interventions to promote such behaviours.

4.4.6 Facilitators and barriers to applying a systems approach

Only one article³⁴⁸ reported barriers and enablers. This article is a process evaluation of a pilot community (Sustainable Eating Activity Change Portland- SEA Change Portland) that participated in the WHOSTOP²³³ programme in Victoria, Australia's Great South Coast region.

4.4.6.1 The process of implementing the systems approach itself is a facilitator

The GMB workshops and "the organic evolution" of the programme in all areas and levels of the system were reported by the steering and community task team members to be helpful. This approach established the ownership of the system by the community, which was achieved by engaging a broad spectrum of people in the community who jointly dissected the complexity and main influences of obesity.³⁴⁸ Furthermore, co-creation teamwork, including sharing information within the steering group, engaging local agencies, and authorities' commitment to integrated working, has been identified to positively impact the programme's feeling of ownership, development, and progression.²⁴

4.4.6.2 Focusing on community assets rather than lacks is a facilitator

Focusing on community assets rather than needs or lacks was helpful in information sharing between members, engaging relevant organisations, forming a relationship with a topic expert, and attaining the commitment of many local authorities (LAs) to participate in the collaboration.³⁴⁸ This can be accomplished by shifting mindsets from deficits to capabilities, highlighting and linking a wide variety of community assets and mobilising the connected assets for action.³⁵⁴

4.4.6.3 Recognising the complex nature of obesity and the need for collective actions is a facilitator

Triggers for personal participation in the programme and motivations for others to participate have been identified as important facilitators of engagement in the process. For instance, the

use of GMB has been found as a powerful tool to promote a shared understanding of the complexities of obesity in the local context and the need for collective actions.³⁴⁸

4.4.6.4 Poor understanding of personal responsibilities within the cross-sectoral team is a barrier

Some identified barriers are miscommunication and confusion observed within the steering group organisation regarding individual responsibilities and roles. As a result, thought processes among members of the steering groups were not always aligned. Furthermore, a lack of support for those working at a lower level was identified within the steering group.³⁴⁸ Another barrier is related to the lack of application of the asset-based community development approach that promotes ownership and sustainability and could have been more effective if it occurred in conjunction with the GMB workshop.³⁴⁸

4.4.6.5 Enhancement for GMB approach

A few barriers are related to the asset-based community development approach. This approach promotes ownership and sustainability, and having it coincide with the GMB workshop could have increased its effectiveness.

4.4.6.6 Poor health literacy among some GMB participants is a barrier

The standard processes of GMB workshops were not adapted to support community members who had minimal health literacy, and no further work was undertaken.³⁴⁸ This may negatively affect the efficiency of the task teams. Another identified barrier is related to unforeseen social and economic shocks. For WHOSTOP, the bushfire impacted the subsequent delivery of interventions,³⁴⁹ which will be even more marked when the impact of COVID is understood.

4.4.7 Quality assessment

Only the quality of two papers^{348,349} was assessed by an appropriate tool based on their study designs. The WHOSTOP³⁴⁹ met 14 of 17 reporting quality items of the CONSORT extension for the stepped wedge cluster randomised trial (Appendix 7). The process evaluation study³⁴⁸ was assessed using the SCAS-EPPI³⁴⁶. The reliability of the included process evaluation findings was rated as a medium, while the usefulness of the findings was rated as high (Appendix 7).

4.5 Discussion

4.5.1 Key findings summary

This review aimed to identify what has been achieved to date in terms of applying a comprehensive systems approach to obesity prevention. This scoping review identified three studies that have comprehensively applied the systems approach to obesity prevention, as defined by the reviewers based on the latest academic knowledge. The review provided a summary of available empirical evidence on the effectiveness, practical challenges, and facilitators in applying this approach. The review also identified the main features of and documented barriers and facilitators to adopting a comprehensive systems approach for obesity prevention. The review also presented a list of screened studies that were reported to have used the systems approach for obesity intervention but did not meet the inclusion criteria. It was also explained why each of these studies did not meet the inclusion criteria. Obviously, a more transparent reporting of the decision process can facilitate a scholarly exchange of experience and thoughts to advance the theoretical, methodological, and practical understanding of this new approach to public health improvement.

This review included five publications^{4,233,347-349} reporting on three eligible studies.^{4,233,347} This number suggests that the evidence base for a comprehensive application of a systems approach

to obesity prevention is limited. Although there is positive evidence, more empirical evidence is needed to understand the application and effectiveness of this approach. Furthermore, no empirical evidence is available from non-Western, developing settings.

4.5.2 Findings in relation to the literature

The scarcity of studies using a comprehensive systems approach may reflect uncertainty around the exact meaning of 'systems approach'. This uncertainty was demonstrated in the high number of excluded studies in this review, a product of self-labelling or inadequate reporting. Some programmes appeared only to implement multi-level, multi-component interventions but "self-identified" as using the systems approach. Notably, a number of studies/programmes that self-identified as having used the systems approach for obesity prevention did not meet the inclusion criteria for intervention development. Moreover, sub-optimal reporting might have also explained the small number of studies meeting the inclusion criteria. The 2019 systematic review also found that the reporting of most included studies lacked sufficient detail.³³³ Similarly, authors of the recent review on different methods used to evaluate various public health interventions also suggested that more attention could be paid to the presentation of complex systems evaluation findings.³³⁵ Therefore, robust and well-reported evidence is needed to improve our understanding of how the systems approach can be implemented practically.

One important impact of this review was the development of a list of practical questions (Table 4-2) led by senior academics with empirical experience of adopting and developing systemic methods to help with reporting intervention studies based on the systems approach.³²⁵ This reporting guidance was published recently, and it can help editors, researchers and other relevant parties to develop, implement, report and review work underpinned by SAP.

Table 4-2: Questions to guide future reporting of a comprehensive application of a systems approach.³²⁵

Intervention stage in a continuous, iterative, and reflective process	Questions to consider
Intervention Development	1. Have the authors clearly defined the public health problem being addressed?
	2. Have the authors specified the theoretical underpinning of the systems approach (e.g., System Dynamics) applied to develop the intervention and justified their choice? <i>Simply saying the intervention was developed using a systems approach is not sufficient.</i>
	3. Have the authors specified the methods (e.g., Group Model Building) applied to develop the intervention and justified their choice? <i>Simply saying the intervention was developed using a systems approach is not sufficient.</i>
	4. Have the authors made any adaptations or methodological innovations to the referred development process to suit local settings or cultures?
	5. If the answer to the 4 th question is YES, have the authors described such changes in sufficient detail to support methodological learning and advancement?
	6. Have the authors clearly defined the targeted intervention community for each intervention in terms of its geographic/authoritative boundaries as well as the size and characteristics of the targeted population?
	7. Have the authors described the environment (physical, cultural, socio-economic, and policy environments) within which the intervention was developed with sufficient detail to allow the readers to understand the development context? <i>Among others, this should include existing interventions/policies and how the local government and key stakeholders viewed the public health problem being addressed.</i>
	8. Have the authors described in sufficient detail the process of identifying and choosing key subsystems/organisations/partners/decision-makers within the system prior to approaching them to develop a collective understanding of the system?
	9. Have the authors described in sufficient detail the process of gaining support from senior leaders of those subsystems/organisations prior to developing a collective understanding of the system?
	10. Have the authors described the subsequent steps involved in the intervention development process in sufficient detail? <i>To answer this question, consider whether the authors provided methodological information related to participants (and other individuals), activities/process, locations, duration, outputs, instruments, and materials? A flowchart is recommended in addition to the description in the text.</i>
Intervention Delivery/Implementation	1. Have the authors clearly defined each intervention community (if multiple communities/cities/regions were included in the study/project) in terms of the geographic/authoritative boundaries as well as the size and characteristics of each beneficiary population?

	2. Have the authors described the intervention environment (physical, cultural, socio-economic, and political environments) of each intervention community/city/region with sufficient detail to allow the readers to understand the intervention context? Among others, this should include existing interventions/policies and how the local government and key stakeholders viewed the public health problem being addressed.
	3. Have the authors specified who were involved in the delivery of jointly identified and prioritized intervention actions and their responsibilities?
	4. Have the authors specified the responsibilities of all individuals and organizations involved in the delivery of jointly identified and prioritized intervention actions?
	5. Have the authors described with sufficient detail how communication and aligned collective actions across diverse action groups/stakeholders were maintained and monitored?
	6. Have the authors described how to ensure a shared feeling of joint ownership (of the intervention) across diverse stakeholders or action groups?
	7. Have the authors described in sufficient detail what were delivered/implemented, including the initial plan and subsequent changes to the initial plan?
	8. If any intervention actions were adjusted, re-designed or terminated in response to results of ongoing intervention monitoring or other causes (e.g., lack of funds or change of leadership), have the authors explained the reasons for such changes?
	9. Have the authors reported the challenges/barriers and facilitators to deliver the intervention?
	10. Have the authors described the nature/sources of funding allocated to support the interventions?
Intervention monitoring and evaluation	1. Have the authors defined the overall evaluation approach (e.g., stepped wedge design, natural experiment or routine data collection)?
	2. Have the authors discussed how the chosen evaluation approach reflects features of systems thinking (e.g., complexities and dynamics)? Following considerations may help to answer this question: <ul style="list-style-type: none"> • Have the authors described and justified methods used to assess how individual intervention actions worked together, interacted with each other and generated changes to the whole system? • Was ongoing monitoring of intervention impact included as part of the overall evaluation work (in addition to endpoint outcome measures)? • Have the authors measured and reported on unintended consequences? If yes, have they reported the methods and results with sufficient detail? • Have the authors described any attempt to understand how the system evolves over time?
	3. Have any of the evaluation outcomes been used to review and update stakeholders' understanding of the system gained prior to intervention delivery?
	4. If the answer to the above question is YES, have the authors described what, when and how ongoing evaluation outcomes were used to support intervention delivery/implementation?
	5. Have the authors reported on the challenges/barriers and facilitators to evaluation of intervention impact?

	6. If the authors adapted/amended an existing evaluation approach/method or invented new methods, have these adaptations/innovations been described with sufficient detail to support methodological learning and advancement?
	7. Have the authors described in sufficient detail what and when impact indicators/outcomes were measured and how?
	If process and economic evaluations were included in a study/project, have the authors described the evaluation approach and methods in sufficient detail (within the same publication or elsewhere)?
	9. If methodological adaptations or innovations were made to traditional process/economic evaluation approaches, have the authors described their approaches and methods in sufficient detail to support methodological learning and advancement?
	10. Have the authors provided other information on study/project results (with reference to established reporting guidance if available) to allow readers to understand and assess results?
	11. If any, have the authors identified, recorded, and reported major changes in the intervention environment (e.g., natural disasters, new public health crises and changes of national policies relevant to the public health problem being addressed) during the intervention delivery/implementation period that might influence accurate evaluation of the intervention outcomes?
	12. If the answer to the 11th question is YES, have the authors discussed the potential impacts of those major changes in the intervention environment to help readers interpret the reported intervention results?

This review found only one article that reported on the effectiveness of the WHOSTOP programme. Therefore, published evidence on the impact of taking a comprehensive approach to obesity prevention is still limited. However, it is aware of several ongoing studies that will publish their evaluation outcomes within the next few years. Hopefully, the proposed reporting checklist will help the academic community report and share new empirical experiences and evidence more efficiently.

Overall, the WHOSTOP positively impacted the health-related quality of life, take-away consumption, packaged snacks among boys and water consumption among girls.³⁴⁹ However, a 'U-shaped' pattern was observed for changes in mean BMI z-scores and overweight/obesity percentages among the intervention communities, whilst these two outcomes remained largely unchanged among the comparison communities throughout the study period. A valuable finding from this study was the suggested explanation (explained in section 3.4) for such findings by the programme's/study's researchers.

First, as planned, implementation support was reduced in the second year to communities in step-one so that they could focus more on recruiting communities to step two. Due to natural disasters, control communities had to delay intervention uptake for two years. For the last two years of the research, the allocated resources were cut by at least half for the first group of intervention communities. Second, the length of an intervention might be critical in determining measured intervention outcomes. For example, a systematic review of 26 studies with a similar age category (7-12 years) as WHOSTOP reported that the most successful intervention in addressing obesity lasted less than a year.³⁵⁵ Future research should pay attention to potential interactions between intervention length and impact. Researchers and authors should also report major changes in the intervention environment and reflect on how such changes might have

influenced intervention outcomes at different time points. This recommendation is included in the reporting guidance under the monitoring and evaluation section.³²⁵

This review highlights that all included studies^{4,233,347} were based in Western, high-income countries (Australia and Netherlands), which raises an important question about the feasibility of applying the systems approach in non-Western and/or developing countries. One challenge might be realising cross-boundary collaboration among authorities and organisations to tackle health issues. For example, a study conducted in a Middle East country found that collaboration among diverse stakeholders is limited due to cultural and gender barriers.³⁵⁶ Moreover, many non-western countries adopted a highly centralised governing model in which the central authority has more strict control over local authorities (LAs). This could be a particular challenge when implementing the systems approach to public health intervention development and implementation, as this approach is bottom-up and collaborative.

Moreover, a centralised government can disempower local councils and not view health promotion or disease prevention activities as politically favourable.^{357,358} These challenges imply that the feasibility of using the systems approach in non-western countries should be a focus of future research. Researchers from non-Western/low- and middle-income countries are encouraged to contribute to the current literature by testing the uses of the systems approach in their settings and reporting any culturally relevant adaptations made to existing processes and tools used by western researchers. Reporting methodological adaptations and innovations is a recommended item included in the proposed reporting guidance.³²⁵

The review identified common features shared by studies that were considered to have comprehensively applied the systems approach to obesity prevention. Similarly, the 2019 review³³³ and the NICE review³²⁹ found that building relationships and community capacity was required to create successful outcomes.

The review identified only one process evaluation³⁴⁸ of an included intervention. This makes it challenging to provide a comprehensive summary of reported barriers and facilitators to applying the systems approach to obesity prevention. However, the identified barriers and facilitators can improve the design and delivery of future obesity interventions that take a comprehensive systems approach. For example, focusing on community assets will create a complete picture of shared motivations for change. This increases the possibility that change efforts will receive widespread support and success.³⁵⁹ Moreover, a strong reciprocal relationship was identified between asset-based community development, collective impact and systems thinking. Using these concepts seems to prevent an intervention programme (at least in the short term) from reverting back to business as usual.^{179,348,360,361} The included process evaluation article revealed that collective impact and systems thinking were pivotal elements of their initiative. Therefore, communities and future research initiatives seeking to use the systems approach may wish to explore ways to implement the overall approach supplemented by a collective impact framework.

4.5.3 Strengths and limitations

This is the first review to identify and assess published evidence of a systems approach for obesity prevention using strict inclusion criteria to encompass all stages of an intervention's life cycle. This is the main strength of this review since previous reviews applied broader inclusion criteria to include traditional multi-setting/-level interventions that did not show evidence of other essential features of systems thinking. A wide range of data sources, outcomes and process evaluation were included to capture all available evidence. Moreover, common features of authentic and comprehensive use of the systems approach for obesity prevention and application facilitators and barriers were identified.

The review also has potential limitations. First, the definition of comprehensive use of systems approach for obesity prevention was determined based on the current academic knowledge and empirical experience. The definition and review may be updated accordingly as the practical application of the systems approach to obesity prevention and other public health challenges are advanced. Second, it is possible that some studies/programmes might have made comprehensive use of the systems approach but were excluded from this review for lacking methodological and process details in associated publications. This might mean that findings on other eligible studies/programmes were not considered in this review. The proposed reporting tool was developed to avoid issues such as these in the future.

Third, evidence for the effectiveness of this approach was identified in behavioural outcomes and QoL. However, this was based on one included study. More research is needed to understand better the impact of adopting a comprehensive systems approach on obesity prevention. Researchers and authors should also report major changes in the intervention environment and reflect on how such changes might have influenced intervention outcomes at different times. Non-western researchers are encouraged to test the approach in their settings and report any culturally relevant adaptations made to existing processes and tools. Reporting methodological adaptations and innovations is a recommended item included in our proposed reporting guidance.

4.6 Conclusions

This review identified only three studies considered to have comprehensively applied the systems approach to obesity prevention intervention. This may be due to the misunderstanding of the approach or insufficient reporting of key processes and methods. Currently, no published empirical evidence is available from outside western, high-income settings. The evidence for the effectiveness of this approach on behavioural outcomes and quality of life was identified

based on one included study. However, given this extremely limited evidence base, no conclusion on the effectiveness of this approach can be drawn yet. This review also identified common features shared by included studies, which may help clarify existing confusion around the meaning and practical application of the systems approach to obesity prevention. Finally, some barriers and facilitators to applying a comprehensive systems approach in practice were identified, and they would help improve the design and implementation of future work.

4.7 Chapter summary and contribution to the thesis

This chapter highlighted the scarcity of studies that have comprehensively applied the systems approach to obesity prevention, indicating that this approach is still a misunderstanding. Furthermore, all included studies were based in non-western populations, indicating the lack of studies in non-western populations. Regarding the effectiveness of this approach, no conclusion can be drawn yet due to the extremely limited evidence base. Moreover, included studies shared common features, such as mapping the systems of obesity, embedding actions within the systems, measuring intervention process, ongoing changes, endpoint outcomes, local leaders leading intervention development and implementation and supporting capacity building. Some facilitators and barriers to applying a comprehensive systems approach in practice were also identified. Finally, the chapter indicated that more well-designed and reported studies are needed, especially from low- and middle-income countries.

This review has not been instrumental in informing the design of other studies in this PhD project. However, this review provided a valuable contribution to achieving the main aim of this thesis- to assess the feasibility of applying CBSA to develop childhood obesity prevention interventions within the Saudi community. Specifically, this review provided principles that should be considered when taking a systems approach to obesity prevention. Examples of these principles are the role of local leaders, partnership and collaboration with other bodies and

sectors, and building the capacity of the local community. Chapter 8 presents more details on how these principles can be used when combined with other studies' findings to assess the feasibility of CBSA in developing childhood obesity prevention interventions within the Saudi community. The next chapter presents an assessment of the readiness of the Saudi community to address childhood obesity.

Chapter 5: Community readiness for obesity prevention among children in Saudi Arabia

5.1 Chapter overview

As discussed in the literature review chapter (Chapter 2) that community readiness is a fundamental element to the successful application of the SAP, the study presented in this chapter addressed the third objective of this thesis: *What is the current stage of readiness in addressing childhood obesity among the Makkah community?* In addition, this chapter introduces the CRM used in this study and its rationale for using it. The findings reported here are crucial for understanding the feasibility of applying the CBSA to developing childhood obesity prevention interventions and making recommendations for improving them. In a nutshell, the overall community readiness score was estimated to be 5 (out of 9), indicating the 'preparation stage'. However, several weaknesses of current efforts were identified, such as a lack of a long-term plan, financial resources, partnerships and community engagement. Interestingly, community members are dissatisfied with the efforts provided and expressed their desire to involve the private sector and expand the efforts to a higher level.

5.2 The Community Readiness Model

The following sections introduce the CRM, its applications, strengths, and limitations.

5.2.1 Introduction

There are several conceptions of change readiness¹⁸¹⁻¹⁸³ and various tools for determining community preparedness for a particular topic or problem.¹⁸⁴⁻¹⁸⁶ A widely used and adaptable tool is the CRM, established by Colorado State University's TriEthnic Center for Prevention Research to assess community readiness.³⁶² The model suggests combining a community's resources, culture, and readiness to solve community challenges successfully.¹⁸⁶ The term "readiness" relates to how ready a group is to act on a concern. Readiness may help forecast a

community's chance to accomplish and support change. According to the model, community readiness is defined as a community's ability or capacity to respond to a critical situation. The foundation of CRM is to guarantee that any programme designed in a community is matched to the resources and knowledge available to address any concerns effectively. The CRM is inspired by two models, including the transtheoretical and Community Development models.³⁶³⁻³⁶⁵

5.2.2 Application of the CRM

The CRM consists of six processes used to solve a particular problem within a community (Figure 5-1). However, for the scope of this project, only processes one to four were adopted. However, the study made some recommendations for appropriate strategies based on the CRM handbook. According to the CRM, the 'community' is defined as a geographical location, a population inside that location, an organisation, or another recognisable community.¹⁸⁶ Importantly, this study is interested in childhood obesity, so it defines community as those community members or authorities who impact children's life and environment within a specific location (Makkah).

Figure 5-1: Steps of the CRM



Adopted from Plested (2006)

Six dimensions of readiness are considered (Table 5-1). The model assigns a score to each of the six dimensions based on nine readiness stages (Table 5-2), ranging from 1.00 (no awareness) to 9.00 (ownership).^{185,186} While the readiness stage serves as a gauge of the existing situation in the community, it also serves as a guide for identifying objectives and methods that will inspire and organise the community to confront the problem.

Table 5-1: The six dimensions of the CRM and its definitions.

Dimension	Definition
Existing efforts	To what degree are policies, programmes, and efforts being made to tackle the problem?
Community knowledge of efforts	How well-informed is the community about current efforts?
Leadership	How much support does the issue have from community leaders?
Community climate	What is the attitude of the community toward tackling the issue?
Community knowledge of the issue	How much are the community members aware of the causes and consequences of the issue and its impact on the community?
Resources	To what degree are resources available to address the issue?

Table 5-2: Stages of community readiness and its definitions.

Number	Stages	Definition
1	No awareness	The problem is not widely recognised as a problem by the community or its leaders
2	Denial/ Resistance	The issue is recognised by at least some community members, but there is little awareness that it may be happening locally.
3	Vague Awareness	Most feel the problem in their community, but there is motivation to address it.
4	Preplanning	Agreement on that something should be made; a group might tackle it, but efforts lack focus and details.
5	Preparation	Leaders initiate planning, and the community contributes modestly to initiatives.
6	Initiation	There is sufficient information, and efforts are currently ongoing.
7	Stabilisation	Community decision-makers provide support for efforts. The personnel is well-trained and experienced.
8	Confirmation/ Expansion	Efforts are established, members support expansion, and local data is collected regularly.
9	High Level of Community Ownership	Local causes, consequences and prevalence of the issue are well known. Evaluation findings are reviewed regularly. Diverse resources and funds have been obtained, and efforts are likely to continue indefinitely.

5.2.3 Uses of the CRM in childhood obesity prevention

The CRM was created to be adaptive to various issues and contexts. The model has been used more often in high-income nations than low-middle-income nations. The CRM has been used to assess the community's readiness for childhood obesity prevention programmes in the US,^{180,366,367} AUS,³⁶⁸ the UK,³⁶⁹ and Italy.³⁷⁰ Moreover, the model was also used to design appropriate and cultural childhood obesity interventions among specific populations such as American Indians and disadvantaged areas in AUS.^{371,372} The silo study from the Middle East that used the CRM to address childhood obesity prevention was in Iran.³⁷³ In addition, the CRM was also used to assess the readiness of a community pre and post-childhood obesity prevention interventions.^{179,368,374}

5.2.4 Strengths of the CRM

Due to its multidisciplinary nature, the CRM can be used to address a wide range of public health concerns. The model is simple to utilise with an easy-to-use topic guide and grading system. In order to assess the level of preparation in various communities, the interview guide can be simply altered to the interesting problem or repeated in other distinct communities to compare the level of readiness.¹⁸⁶

A systematic review of 40 studies using the CRM concluded that the model is appropriate for designing and assessing complicated community health initiatives, considering its versatility to suite different community definitions and challenges.³⁶² The CRM findings can assist communities in selecting prevention strategies that are suited for their particular situation. In addition, at each level of readiness, the model directs the formulation of aims and strategies that enhance action readiness. For example, communities with lower levels of leadership readiness on obesity among children might have leaders who are unaware of the issue of obesity or show little desire to take any meaningful action. In such a case, the model would serve as a guide to

educate community leaders on the issue of childhood obesity, resulting in enhanced preparedness to consider and implement evidence-based childhood obesity prevention programmes.

5.2.5 Limitations of the CRM

The CRM has been criticised for the method with which key informants are identified. The method of identifying key informants might affect the model's outcome. For example, those most involved in or concerned with a problem may be more prepared than the general population. As a result, the evaluation of preparedness may represent the opinions of a "vocal minority".³⁷⁵ Additionally, the minimal number of proposed interviews is criticised for failing to adequately reflect a whole community's perspectives. Moreover, the model is based on a scoring system and ignores qualitative results that are rich, insightful, and valuable as design tools for interventions.³⁷⁶ However, as long as specific procedures are followed to overcome these shortcomings, the advantages of utilising the model exceed the possible drawbacks.

5.3 Rationale

The literature review chapter (section 2.9.3) has clearly highlighted the international calls for applying the systems approach to address complex public health issues, including obesity. As a result, the systems-based approach replaces discreet initiatives that use linear logic models to tackle complex public health issues.^{3,377} However, co-created, system-level interventions can only occur when the community has the capacity and is ready to change. The community's willingness or reluctance to embrace the desired change is a critical determinant of effective intervention approaches. In addition, a strong feeling of community cohesiveness and the capacity to collaborate may be critical factors in determining the success of community

efforts.³⁷⁸ Therefore, it is critical to assess community readiness to customise the intervention to each community's degree of readiness, ensuring maximum involvement and effect.^{179,180}

The CRM plays a vital role in understanding contextual constructs (community capacity) that are important to consider before applying the CBSA to address obesity within a community. A better understanding of contextual constructs (community capacity) would enable us to judge the feasibility of applying the CBSA within the Saudi community, particularly when combined with other components of this PhD.

5.4 Aim and research questions

This study aimed to assess how ready the Makkah community is for addressing childhood obesity. The following two sub-questions were set to fulfil the main aim:

- a) What is the current stage of readiness in addressing childhood obesity among the Makkah community?
- b) How do the CRM dimensions and stages of readiness contribute to our understanding of the feasibility of applying the CBSA to address the issues of childhood obesity and inform recommendations for improving feasibility?

5.5 Methods

5.5.1 Research design

Online semi-structured interviews with key informants were conducted from April to August 2021 to assess community readiness using the CRM guidelines.¹⁸⁶ In-person interviews were not feasible due to restrictions implemented to control the spread of COVID-19. The interview guide with six sections representing the dimensions of the CRM was translated into Arabic by a native Arabic speaker. Another independent Arabic researcher also verified the Arabic

translation version. All interviewees were instructed to limit their responses to the discussion of obesity among under-18-year-old children in their community.

5.5.2 Research setting

This study was conducted in Makkah city, the second-largest urban area in SA. This city is situated in the Western region of SA. It is considered the most important city in the country. The area of the city is about 1200 square kilometres, with a population of 1.5 million. The city, a one-of-a-kind location, is a holy city for all Muslims worldwide, so it attracts more than three million people during the pilgrimage season (Hajj Season) and millions during the rest of the year. Because of the importance of Makkah, the Saudi government has provided and is still providing many services, including health services to residents and visitors. In addition, billions of dollars are paid annually to develop this city at all levels, facilitating residents' and visitors' lives. The city comprises approximately 61 districts, most classified as high-end urban neighbourhoods, and is still expanding. The prevalence of childhood overweight and/or obesity in this city is high, with higher rates in girls than boys.^{293,379,380}

The city of Makkah was chosen as the research setting mainly because it is the researcher's hometown. In addition, the researcher has worked for several years on several health projects in this city and worked in the academic field as a lecturer in the Department of Health Promotion. The researcher, based on his previous work, knows in advance individuals, authorities and organisations who are responsible for providing a healthy lifestyle in the community. Therefore, the researcher's full knowledge of this city was expected to facilitate data collection.

5.5.3 Key informant identification

A list of the names of LAs and individuals was compiled to identify key informants (Table 5-3). This list was based on the CRM definition of key informants, in which key informants are

defined as individuals who are the best to provide insight into local actions. In addition, key informants should be from various sectors within the community to collect information from various perspectives.¹⁸⁶ Further criteria for the key informants were set to overcome the criticism of CRM. These criteria include that key informants should have (had) knowledge and experience in relevant local intervention programmes or policies regarding public health and segments of community leadership. Some community members, such as doctors, were ruled unfit for interviews, as it was essential to focus on community residents rather than health workers. In addition, it was considered that the interview questions would be too difficult for children to answer, so they were excluded. Parents were also excluded as they were unexpected to understand the larger community's situation comprehensively.

Table 5-3: Potential authorities and key informants

Category/Sector	Potential Stakeholders	Their Responsibilities and Reasons for Selecting
Governmental bodies	Public Health Department	Overseeing the daily operations of public health services within the local community.
	Department of School Health Affairs	Their roles directly related to providing students with health and awareness services by implementing health programs and school events.
	Makkah Development Authority	Responsible for developing infrastructure, including plans for smart Makkah and reforms needed to improve human lives.
Governmental bodies and Education and research	Department of Health Education and Health Promotion	These are academic, research and education departments with extensive work experience with the local community for over 15 years. The reason for selecting academic members from these departments is that they have full knowledge of the local community needs, skills and resources. <u>Only academic members who have experience conducting community health programmes are eligible to participate.</u>
	Department of Physical Education	
	Research centres	
	Community Health Education Centre	
NPOS and Private	Health Promotion Centre	Concerned with identifying and developing different programmes/activities to meet the needs of the local community
	YAQD	Providing the Makkah community with professional health advice for adopting a healthy lifestyle and conducting obesity research studies.
Individuals	Obesity experts	They should have already worked to tackle childhood obesity in the local community. They will be recruited from

		previous efforts/programmes to prevent obesity in the Saudi community.
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5.5.4 Recruitment of key informants

Key informants were purposefully chosen to represent various sectors to guarantee a diverse spectrum of perspectives within the community. A recruitment email (Appendix 8) was sent to each potential authority, organisation or individual, inviting them to participate. This recruitment strategy was problematic as most potential participants did not respond to the recruitment email. So, it was followed up by calls or texts using their social media accounts. Time commitments were the most common reason for refusing to participate in this research. Those who agreed to take part received an information letter (Appendix 9) and an informed consent form (Appendix 10) asking them to fill it out and return it before the interview. On two occasions, sampling used a snowball strategy, in which another potential key informant was suggested by an interviewee and then was contacted and recruited. The SPS-REC at the University of Bristol approved this research project on 24/03/2021 (Reference: SPS REC/20-21/124) (Appendix 11).

Even though I had difficulties in the recruitment process, those who may be considered key informants did participate. As a result, the key informants of this study are inevitably representatives of the Makkah population, and that saturation has been reached.

5.5.5 Data collection

5.5.5.1 Interview process and topic guide

According to the CRM guidelines, interviewing 4–6 key informants yields a better knowledge of a community issue since each participant is invited to speak in the larger community context.¹⁸⁶ However, in qualitative research, researchers aim to achieve a theoretical saturation,

where more interviews are unlikely to provide any new information.³⁸¹ This study aimed for 'theoretical saturation'; hence it enlisted more key informants than the recommended number. Theoretical saturation was determined iteratively at the community level by thematic analysis of all transcripts to find any extra topics compared to the preceding transcript. When the last transcript contributed little new information or themes, saturation was reached.³⁸¹

The CRM tool comprises 36 open-ended questions (Appendix 12) that target six different aspects of preparedness. The issue was defined as "obesity among children under 18 years in Makkah city". I translated the topic guide into Arabic, and an independent Arabic researcher reviewed it to ensure its accuracy and that the questions were worded to allow participants to elaborate on their thoughts. The interviews were done in Arabic by a native Arabic researcher (myself) trained in public health and obesity prevention at a doctoral level. In addition, the CRM interview guide was pilot tested with a community key informant to check and optimise choices of key phrases and terminology, discussion flow and culturally appropriate translation. Most participants were in quiet and familiar places during the interview, such as work and home offices. Interviews lasted for around 27 to 120 minutes, with an average of 45 minutes.

Prior to each interview, it was explained to each participant that they were free to terminate the interview at any time for any reason and that their participation in the research was voluntary. However, once data analysis has begun, data cannot be retracted. Interviews were conducted online and audio recorded. After each interview, I summarised the key points that the participants supplied and requested them to remark on the correctness of the summary and offer clarification or add any new information to maximise the credibility of the data.

5.5.5.2 The trustworthiness of the data collection process

According to Lincoln and Gupta (1985), there are four components of trustworthiness in qualitative research: credibility, dependability, transferability, and confirmability. The

following subsections briefly describe these components and what measures were taken to ensure the trustworthiness of the data collection process in this study.

5.5.5.3 Credibility

This component is related to the degree to which the results of qualitative research are in line with reality.³⁸² The credibility of the findings in this study was sought by using member checking and peer debriefing. A member check was achieved in this study by ensuring that each interviewee received a summary of the conversation at the end of each interview. Interviewees were also asked to make any corrections or additions to that summary. Regarding peer debriefing, supervisors served as debriefers during the frequent meetings conducted during data analysis. This provided a chance to give critical feedback on data interpretation and flag any potential bias.

5.5.5.4 Transferability and dependability

This component is related to the extent to which qualitative research findings may be transferred to other settings or used in new situations.³⁸² The dependability component is related to the extent to which processes for doing research are recorded, enabling someone outside of the study to monitor, audit, and criticise the research process.^{382,383} To achieve these two components, the data collection and analysis processes were reported transparently in detail. For example, the topic guide is attached as an appendix. In addition, in the results section, participant area of work and ID number are indicated to allow readers to check the diversity (sources) of quotes selected.

5.5.5.5 Confirmability

This component is related to the extent to which the researcher's findings and interpretations are drawn from the data.³⁸³ This component was achieved in the current study by providing

original quotes to illustrate themes identified and transparently describing the data analysis process. Moreover, all interviews were carried out by the same researcher (myself), which helped to improve the conformability of the data collection process.

5.5.5.6 Reflexivity

The trustworthiness of this qualitative study was also enhanced by using reflexivity during data analysis and interpretation of findings. Reflexivity relates to the process through which the background, position and assumptions of the researcher are acknowledged, and the role of the researcher in analysing and interpreting the data is reflected.³⁸⁴ Hence, qualitative researchers are recommended to acknowledge any potential sources of bias and any beliefs and experiences they may carry to the study. The following section reflects on how my role, experience and knowledge influenced the research process:

As a lecturer in the health promotion and education department within the local university in Makkah with a bit of experience in working with LAs to address NCDs within the community, I am aware that my knowledge and experience may have shaped my beliefs and thoughts about childhood obesity prevention in SA. In addition, before entering this PhD, I participated in several symposiums to discuss the challenges of addressing noncommunicable diseases in Makkah. These previous experiences provided me with knowledge about the challenges of addressing NCDs within the Saudi community. Thus, I am aware that I had certain preconceived notions about the challenges of addressing NCDs, e.g., childhood obesity in SA. However, I aimed to maintain non-judgmental during the interviews with participants to enhance my reflexivity during the research process.³⁸⁵ I endeavoured to establish a friendly and warm atmosphere and listen actively to the interviewees. In addition, to limit my influence, I asked probes to help clarify and reflect. I also asked interviewees for examples and elaboration to gather wealthy information. Moreover, I spent time after every interview taking notes and

recording some details, such as a reflection on questioning styles and whether the participant had shown any hesitation to give information. In addition, before the data collection phase, I received formal training in qualitative interview procedures, building on my expertise with semi-structured interview approaches.

Furthermore, being an “insider” researcher greatly assisted me during the design and data collection. For example, my previous experience recruiting LAs helped me to design recruitment strategies for this PhD research and use the most effective strategies to reach decision-makers. Moreover, it is important to understand how interviewees perceived me, as they are often eager to ‘please’ the interviewer by saying what they believe the interviewer wants to hear.³⁸⁶ All participants were unknown to me and unaware of my job as a lecturer in the health promotion department in Makkah. In addition, participants were also unaware that I was born/raised and lived in the same city.

During data analysis, I tried to detach myself from my experiences and prior understanding of childhood obesity prevention within the Saudi community. However, it is possible that my background and experiences might have impacted data collection, analysis and findings interpretation, even though every effort was made to be neutral and no information about my experiences or personal opinions was disclosed prior to or during the interviews. However, the risk of bias was diminished by increasing transparency of the research process and acknowledging prior experience, background and perceptions.

5.5.5.7 Transcription and data management

All interviews were audiotaped and transcribed verbatim into Arabic to familiarise myself with the collected data. Each interview was transcribed immediately after the interview to ensure that early data familiarisation was achieved, exported into a word document and stored in the University of Bristol Cloud. Participants’ names were pseudonymised to avoid disclosing

information that may be used to identify individuals. Even though the transcription process was a part of the data management, it was helpful in familiarisation with the collected data through frequent listening to the recordings and writing the transcripts.

5.5.6 Data analysis

5.5.6.1 Thematic analysis

Data analysis was conducted using the original language of the interviews (Arabic). It is recommended to carry out the analysis of transcripts in their original language since translating each transcript into English may influence the data and thus finding trustworthiness.^{387,388} It takes a long time and costs a lot of money to translate an interview since a good translation requires a back-and-forth translation to verify the translation. Moreover, some expressions or terms specific to the Saudi culture could be lost during translation. Therefore, analysis using the transcripts' original language is suggested to avoid misinterpreting interviewees' responses.³⁸⁷ However, the identified themes and the illustrative phrases were translated into English by myself and checked by a bilingual researcher.

Interviews were transcribed verbatim by the researcher (myself) using NVivo transcription paid service, and then all transcripts were rechecked against audio recordings. All transcripts were anonymised to protect participants' data. Qualitative data analysis software, such as NVivo, could not be utilised during data analysis since they are incapable of dealing with Arabic. Therefore, transcriptions were manually coded and analysed using paper copies, which were then entered into a spreadsheet document in a tabular style. The analysis process was done in Arabic by a native Arabic speaker (myself) who also conducted the interviews and translated the illustrative quotations to ensure the contextual and cultural implications were accurate.

Thematic analysis (TA) was conducted firstly, as described by Braun and Clarke (2006)³⁸⁹ to help interpret the preparedness levels. TA was conducted in the first instance to help familiarise transcripts, determine theoretical saturation and have a thorough comprehension of participants' attitudes, views, and experiences. First, the transcripts were prepared by clustering respondents' sentences/phrases that were similar in meaning. Commonly, these clusters indicate a single point or thought stated in response to a question or comment from the interviewer. Then, these chunks of text groups were viewed as blocks to which one or more codes might be assigned. Following that, major themes and sub-themes were identified by carefully reading the transcripts. After compiling the list of themes, transcripts were re-examined for occurrences of newly discovered themes.³⁷¹

5.5.6.2 Scoring system

Scoring was done independently by two researchers who followed the usual anchored scoring process to score the six dimensions in each interview (Appendix 13). Each dimension was given a number between one and nine, with one representing "no awareness" and nine suggesting "strong community ownership." Each dimension's lowest rating statement was used to rate each transcript. If the transcript did not confirm the statement, the scorer went on to the following statement till confirmation was found. To agree on all readiness scores, scorers reviewed variations in scoring and checked the scoring guideline. Scores were rounded down for each interview to ensure the CRM scoring criteria for the assigned readiness stage were met. The total score for the community was determined by averaging the results from all interviews for the six dimensions.

5.6 Results

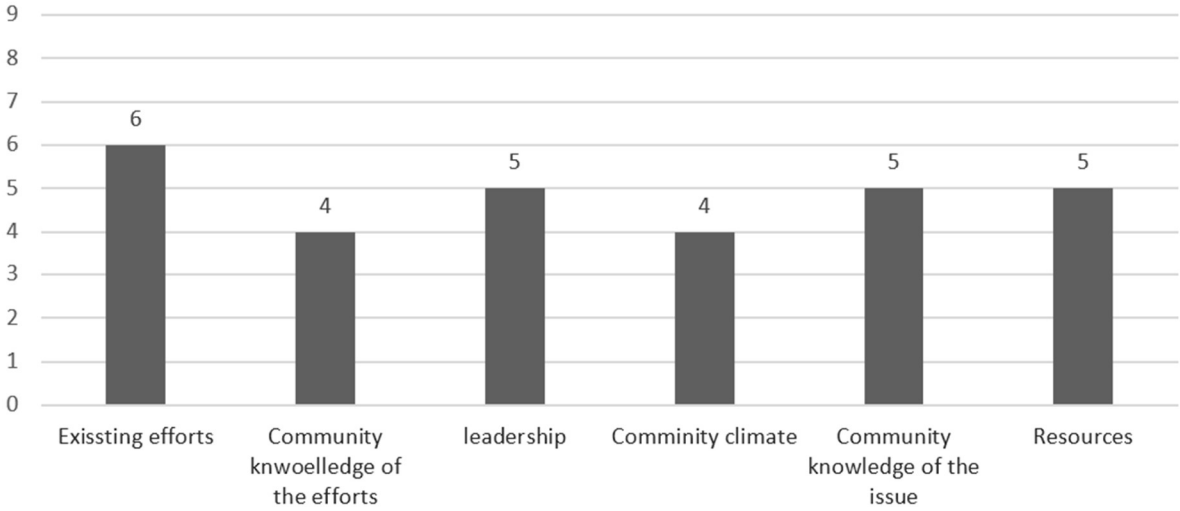
5.6.1 Characteristics of key informants

Eight in-depth interviews with key informants were conducted. All Participants were male community leaders from different sectors, reflecting the current leadership context in the research setting. They were from the education department (n=2), academia (n=1), health promotion and public health department (n=2), public health adviser (n=1) and non-profit organisations (NPOs) (n=2). Participants' years of experience in childhood obesity prevention varied from 5 to 35 years.

5.6.2 Community readiness score

Figure 5-2 below provides the community's readiness scores for each dimension and the average scores. The overall community readiness score was 5, equating to the 'preparation stage'. This refers to the mid-level of the readiness of a community. Once a community reaches this stage, it means a) at the very least, most people in the community are aware of local initiatives; b) leadership actively encourages the continuation and improvement of existing activities as well as the development of new initiatives; c) there is a sense of worry in the community, and they want to take action; d) community members have a basic knowledge of the origins and effects, as well as the indications and symptoms; and finally e) some resources have been identified that might be utilised to expand efforts; leaders or community members are actively attempting to acquire these resources. Community readiness scores are summarised per dimension in the following sections, using qualitative data to explain the scores.

Figure 5-2: Community readiness score by dimension



* A scale of 1 to 9 is used, with 1 representing the lowest and 9 representing the greatest score.

5.6.2.1 Dimension A: Existing Community Efforts

This dimension was rated the highest among all dimensions (=6), which equated to the initiation stage. The qualitative analysis found the following two subthemes of this dimension.

5.6.2.1.1 Existing efforts

Qualitative analysis revealed some efforts to address childhood obesity in the community. School-based efforts and the national obesity programme were consistently identified as an effort, policy or programme to address obesity among children. These efforts include monitoring the adherence of the school canteen to the school food policy. In addition, after schools' clubs providing exercise and play were identified as an effort of obesity prevention among children:

'We have policies in the Ministry of education. We cooperated with health authorities to monitor nutrition in school canteens. The Ministry is diligent in

that it has placed controls and regulations on unhealthy food in schools.' (P3- Education Department)

'They have a program called Live Healthy. They try, I mean, frankly, and they seem to be trying to raise awareness of people in social media.' (P4-Health Promotion Department)

'There are school health programs, and the national obesity control program in the MOH and other activities are done by other sectors' (P6- NPO)

'They are after school sports clubs for children and football academies. The child exercises in it for three days, and this is especially for children aged six years and above' (P1- NPO)

Moreover, the most mentioned effort by participants was the public health campaigns to raise awareness of obesity. These campaigns are launched regularly in malls and schools during World Diabetes Day and World Obesity Day. Furthermore, some participants considered local gardening and walkways efforts as examples of addressing childhood obesity within their community:

'Gardens and walkways exist with facilities to move and play.... The events and activities are done in malls and other places and raise awareness about obesity, which happens once every three months'. (P1- NPO)

'There are simple efforts done by some volunteer and academic groups such as public health and social media campaigns' (P5-Public Health Department)

'During the last four years, obesity efforts have been widespread in malls or during World Diabetes Day, World Obesity Day, the walkway' (P2- Education Department)

5.6.2.1.2 Limitations of existing efforts

Key informants identified some weaknesses of the current efforts. These included current efforts are seasonal, short and business as usual (routine works) which are done only to complete data:

'Seasonal efforts as well as efforts that have an official nature, administrative payment, and completing data and numbers as if it were routine work. It is not the work that it should be' (P7-Public Health Advisor)

'There are no programs for the whole year, for example, that children can benefit from. There are no activities and things in neighbourhoods, walk-up areas, or entertainment that children benefit from. There are no activities, programs, events in the neighbourhood' (P1- NPO)

Another weakness includes non-systematic and institutional efforts that align with the lack of well-structured programmes:

'Prevention efforts are non-systematic, non-institutional efforts that are poorly linked to policies' (P7-Public Health Advisor)

'But we are talking about a well-structured program, for children in particular, which needs improvement' (P6- NPO)

Some key informants discussed the lack of communication between schools and parents regarding obesity efforts delivered within schools. In addition, schools' administration and their adherence to school food policy were identified as a weakness of current school-based efforts:

'The community does not know about it and no communication between schools and homes and family' (P7-Public Health Advisor)

'There are those who violate the regulations and instructions and bypass them. The school administration uses income from the school canteen to implement its activities and programs. Adhere to school policies not correctly. This is one of the wrong practices in schools. There is a contradiction between action and hope. For example, you say unhealthy foods should be avoided in schools, and in the end, you find that what in the school canteen are only drinks that contain sugar, fried potatoes, etc.' (P3-education department)

Notably, a key informant discussed the lack of evaluation of current or past efforts in the community and pointed out that the central issue of current efforts relies on the lack of community engagement and who designed these efforts and who is responsible for delivering them:

'These efforts need scientific evaluation, and if it was evaluated, who evaluated them...An important question remains who designed these efforts. Is it scientifically evaluated or designed... there is a weakness in determining responsibility. Is it the responsibility of public education and school health? or the MOH, or those in charge of school feeding... The community itself is not involved... they are not engaging the community (P7-Public Health Advisor)

5.6.2.2 Dimension B: Community Knowledge of The Efforts

This dimension scored (=4), which equated to the preplanning stage.

Qualitative analysis revealed that some key informants found it hard to provide an overall rating on community knowledge of efforts. In contrast, others underestimate the importance of community knowledge about efforts:

'I cannot give you statistical information as I do not have it' (P3-Education Department)

'I think that a minority, maybe five or ten who know about these efforts, and I think that I know there is a program called Rashaqa, this information is up in the air' (P7-Public Health Advisor)

Notably, social media is the most popular channel to deliver the message of current or past efforts to the community members:

'I mean, especially through social media' (P4-Health Promotion Department)

'There are many channels that deliver the message to them, whether direct or indirect channels from the organisation or in the social media'
(P6- NPO)

Key informants suggested a shift in how community members are informed of childhood obesity through TV, social media campaigns, and proper communication between schools and parents:

'I expect thirty to forty per cent of people know about these efforts, but there should be using TV channels and social media' (P2-Education Department)

'If you want to make the program a known program, you must link it to a certain procedure. For example, if a father agrees to this program, filling out a form, I see the program, I sign it after two weeks, three. Write a report on it' (P7-Public Health Advisor)

'Official sites/places so people can see it and know about it' (P6- NPO)

5.6.2.3 Dimension C: Leadership

This dimension scored (=5), which equated to the preparation stage. The thematic analysis found two subthemes, which are detailed below.

5.6.2.3.1 Concern and support

On a concerning level, most key informants indicated that childhood obesity prevention is of moderate to high concern among leaders, particularly leaders working in governmental agencies. The MoH is the most governmental body mentioned by interviewees, followed by the Ministry of education. However, a few interviewees expressed a low concern among authorities due to the weak efforts implemented to tackle childhood obesity in their local community:

'The concern is very high from government agencies' (P1- NPO)

'Undoubtedly, there is a concern regarding childhood obesity, but there is no action' (P5- Public Health Department)

'Low concern.... because leaders use a firefighting method.... the person responsible is always thinking of quick wins' (P7-Public Health Advisor)

'I see all the capabilities are available to all authorities and leaders, but there is no one to initiate... no one has adopted this issue' (P4-Health Promotion Department)

On a support level, all key informants indicated that most leaders provided indirect support by giving approvals and facilitating the organising efforts for childhood obesity prevention. However, some participants stated that there is no budget allocated particularly to childhood obesity prevention, but there is a budget for health programmes in general. The community leaders were supportive of initiatives aimed at preventing childhood obesity. However, this support does not include financial resources:

'All leaders are ready to support you and give you approvals to initiate your programme/activity but do not tell them to support you financially'
(P1- NPO)

'Financial support is not like what it was in the past. It is temporary and not permanent. Sustained support is not yet' (P3-Education Department)

'There is no budget allocated to childhood obesity prevention. There is a budget for health programs in general' (P6- NPO)

'Unfortunately, the financial support is weak' (P7-Public Health Advisor)

5.6.2.3.2 Priority and cooperation

Some participants mentioned that addressing childhood obesity is a low to moderate priority for community authorities. Few participants stated that addressing childhood obesity is a high priority only on paper, and nothing is implemented on the ground. Leaders' busy schedules and other work were mentioned as a reason that prohibited authorities from prioritising measures to combat childhood obesity:

'On paper, it is a priority, but in reality, there is nothing' (P1-NPO)

'Let us say a moderate priority given to childhood obesity prevention'

(P2-Education Department)

'I do not see anyone taking the initiative. I do not see anyone seeing this issue as a priority... I do not see anything on the ground that is unreasonable' (P4-Health Promotion Department)

'I see that what is done to childhood obesity prevention indicates a weakness of its existence in the priorities list... Leaders are busy with their regular business' (P7-Public Health Advisor)

Some key informants raised concerns regarding the lack of collaborative efforts to address childhood obesity in their local community. The interest from authorities was sometimes attributed to not having collaborative work to address childhood obesity. Few participants mentioned that majority of efforts regarding childhood obesity are done by the MoH and other authorities working separately. Some participants called for collaborative work to address childhood obesity as the practical collaborative efforts done during Covid-19:

"Only the MOH is working to reduce obesity...but other parties do not participate. There is no participation. We did not see participation from other parties." (P2-Education Department)

"All these parties cannot cooperate and create efforts to prevent childhood obesity! As they did during covid-19, there was great cooperation between sectors in light of the Corona pandemic. Frankly, there are some efforts, but each authority working alone" (P4-Health Promotion Department)

5.6.2.4 Dimension D: community climate

This dimension scored (=4), which equated to the preplanning stage. This dimension covers themes such as community support for prevention efforts against obesity among children and community variables that may influence the climate for combating childhood obesity.

5.6.2.4.1 Community involvement and attitudes

Most key informants believed that the local community members recognised the importance and priority of childhood obesity prevention efforts and stated an overall unfavourable attitude toward childhood obesity:

'Almost half of the society recognises the importance and priority of fighting childhood obesity.... few might financially support such as businessmen' (P4-Health Promotion Department)

'For members of society up to now, it may be a primitive priority, and there are simple efforts made by some specific persons to educate people about childhood obesity.' (P5- Public Health Department)

'Childhood obesity prevention is a secondary priority for community members, not a high priority.' (P7-Public Health Advisor)

Moreover, some participants noted that although community members support efforts to tackle obesity in children, a few are involved in those efforts:

'Few community members participate in the development and improvement of efforts to combat childhood obesity' (P2-Education Department)

'Few are involved in shaping and improving childhood obesity prevention efforts' (P5- Public Health Department)

Furthermore, all interviewees mentioned that most community members support the expansion of childhood obesity prevention efforts. However, most key informants reported that the support of community members to create and/or expand obesity prevention efforts does not include financial support:

'They do not have a problem with the expansion of efforts, and they can support moral but not financially' (P2-Education Department)

'Many support the expansion of efforts' (P6- NPO)

'The majority, if they do not pay from their pocket, want programs' (P7-Public Health Advisor)

A few participants stated that if the proposed programmes/efforts are presented clearly with a clear goal, community members are willing to support them financially:

'If the projects are presented clearly, the community has no problem to support' (P6- NPO)

'Financially support, it is possible if the picture becomes clear and the goals are known, and especially if it will have an impact on their children's weight' (P 7-Public Health Advisor)

5.6.2.5 Dimension E: Community knowledge of childhood obesity

This dimension scored (=5), which equated to the preparation stage.

Key informants revealed that community members have a moderate to high level of knowledge regarding the issue and are aware that obesity in children is attributed to the lack of exercise and unhealthy foods. In addition, they mentioned that community members have a great knowledge of childhood obesity signs and symptoms and limited knowledge of its consequences:

'All community members have great knowledge, but not detailed knowledge about consequences' (P3-Education Department)

'All members of society know that nutrition and physical activity prevent or stop childhood obesity' (P1- NPO)

'They all know eating unhealthy food, and lack of exercise are causes of obesity in children' (P 4-Health Promotion Department)

Furthermore, key informants expressed that the critical current issue among community members is the lack of knowledge on preventing or avoiding childhood obesity. They stated that community members desire to prevent obesity in children, but there are no effective efforts within the local community:

'They know the problem, but they do not know how to avoid this problem.' (P5- Public Health Department)

'Most people want to prevent obesity only by preventing children from overeating. While the issue is broader than that and much deeper.' (P7- Public Health Advisor)

Finally, some interviewees described some misconceptions among community members about childhood obesity causes, with limited information being provided to address those misconceptions:

'Providing information about misconceptions about obesity is very weak.' (P1- NPO)

'No efforts to correct misconceptions about childhood obesity and this is what we need, brochures, leaflets distributed in schools for children' (P2-Education Department)

'Childhood obesity is not serviced from this point of view, the fact that it has a feeble chance of being identified in the media.' (P7-Public Health Advisor)

'There is an ease in finding information. It is true that it can be overthrown in unreliable sources, but it has become easier.' (P4-Health Promotion Department)

5.6.2.6 Dimension F: Resources

This dimension scored (=5), which equated to the preparation stage.

Key informants identified several issues related to resources, including the existence of public health experts. For example, a key respondent noted that health professionals lead local efforts and lack public health experts, and limited training is provided to the local community:

'White coats guide local efforts...We do not have enough public health experts specialising in childhood obesity.... Training is missing' (P7-Public Health Advisor)

Financial resources were the most significant barrier to initiating childhood obesity prevention within the local community. Nearly all key informants confirmed that financial support allocated to childhood obesity prevention is insufficient and weak. In addition, few participants reported that financial support from LAs is codified and depends on how projects are marketed and presented to local leaders and the benefits of such projects to the local community:

'It is tough to reach financial supporters' (P4-Public Health Department)

'Financial support is codified; the government has a specific budget, and I do not think it is enough.' (P6- NPO)

'Financial donations depend on the marketing of the project' (P4-Health Promotion Department)

'A very big effort is needed to get donations; I have experience, and I was struggling.' (P1- NPO)

Some participants expressed their dissatisfaction with the current financial support and would like to increase the financial support directed to combating childhood obesity in their local community:

'Donations and financial support are negligible and weak, and I do not think it amounts to what is required.' (P7-Public Health Advisor)

'Current financial support might continue. Even if it continues, it is weak. We want something bigger.' (P 2-Education Department)

Moreover, some key informants pointed to the need to allow the private sector to fight against childhood obesity, whether by financial support or establishing activities and programs:

'The government runs current efforts; it is the government in the first place'
(P7-Public Health Advisor)

'The MOH must support and give room for the private sectors to participate.... We are a society that has a problem. Today, service and social responsibility in private sectors is weak.' (P1- NPO)

Furthermore, nearly all key informants indicated that the most vital resource in their local community is the plentiful volunteers that local leaders had not accounted for.

'Volunteers are available, and they are just waiting for the call' (P3-
Education Department)

'Volunteers are plentiful' (P4-Health Promotion Department)

'Volunteers are available, and this is an untapped component.' (P7-Public
Health Advisor)

5.7 Discussion

5.7.1 Key findings summary

This study aimed to investigate how ready the Makkah community is to address obesity among children under 18. Eight interviews were conducted with key informants. Overall, a readiness stage of 5 was attained (the Preparation Stage). According to the CRM,¹⁸⁶ a community at 'the preparation stage' means that community leaders actively begin planning, and the community provides modest support for initiatives. This study shows that efforts to tackle childhood obesity in the Makkah community are in place, but the community is unaware of them. These efforts were incompatible with the community's awareness of childhood obesity and their desire to expand and upscale efforts. Findings suggested a mismatch between community members and leaders who execute obesity prevention projects within the local community. This mismatch means community leaders are not aware enough of the needs in the area, leading to the design of ineffective interventions and perhaps the reluctance of community members to engage in such efforts. Moreover, the mismatch could explain the key informants' dissatisfaction with addressing childhood obesity in the local community.

'Existing Community Efforts' dimension had the highest readiness score of all the CRM dimensions, followed by three dimensions (leadership, community knowledge about the issue, and resources) that had the same readiness score. On the other hand, the 'community knowledge of efforts' dimension received the lowest score. These findings suggest that the Makkah community is knowledgeable about the issue and has active leaders who have implemented efforts to address obesity among children aged under 18 years. According to the CRM guidelines,¹⁸⁶ all dimensions of readiness must be approximately at the same level before the entire endeavour can be effective and succeed. As a result, efforts should begin with the dimensions with the lowest scores. Given the Makkah community's readiness scores, targeting

the dimension of 'community knowledge of efforts' would be the most suitable first intervention focus since it has the lowest readiness scores. Hence, there is a need to inform the community about the existence and aim of any initiatives, notwithstanding the findings of the qualitative analysis indicating the need to expand and upscale efforts.

This study reveals substantial gaps in efforts to prevent and control childhood obesity in Makkah city. The qualitative analysis of the interviews indicated that existing efforts in the local community are short-term and infrequent. Most community members were unaware of the presence or purpose of current efforts. In this context, the CRM guideline recommends using specific strategies for each dimension to raise awareness in the community regarding the addressing efforts.¹⁸⁶ Moreover, another issue from the qualitative analysis is the lack of agreement among LAs on the priority of addressing childhood obesity. Hence, strategies to raise authorities' understanding of the significance of childhood obesity prevention are required to secure their support for extending and scaling up obesity prevention programmes in the local community.

The qualitative analysis highlighted the most critical problem regarding available resources, which is the sustainability of financing for childhood obesity prevention. This demonstrates the need to enable residents to take ownership of activities/programs so that when resources are curtailed, they may rely on their dedication and come up with creative solutions, such as holding a fundraiser. Given the Makkah community's generosity when planned efforts are presented and marketed well, as reported by key informants, this suggestion may be feasible. Additionally, encouraging residents to take ownership of obesity prevention programmes is compatible with the ideals of community-based research.³⁹⁰

Another central issue in the Makkah community's obesity-related activities/programmes is the dearth of evaluation for current and previous efforts. As a result, local leaders must be aware of

the critical nature of evaluation and the need to allocate a budget, particularly for evaluation. In addition, evaluating efforts, publicising their successes, and demonstrating their benefits may help motivate others to participate and raise community awareness of the problem.¹⁸⁶ Furthermore, another issue is the limited communication and cooperation among various government agencies, which may explain the conflict among LAs on the priority of tackling childhood obesity. Therefore, local leaders must build a cooperation and communication strategy, define common goals, exchange information, and better use available resources.

Saudi ministries of Health and Education are responsible for most efforts to combat obesity in the community, with a noticeable absence from the private sector. Therefore, there should be a new area for the local government to establish partnerships with various industries within the private sector to fight against childhood obesity. In addition, partnerships offer new horizons for growth by recognising and using the strengths and capabilities of each partner and finding novel ways to use them for the common benefit.³⁹¹ Partnerships among LAs and other relevant organisations could be beneficial in the case of childhood obesity prevention, where interventions are multifactorial and complex. Furthermore, partnerships may help ensure the sustainability of obesity prevention efforts by developing a common awareness of the problem and typically mobilising extra human resources to improve engagement and implementation.³⁹²

Community engagement in programmes and activities to reduce obesity in the local community is strikingly lacking, despite the well-established relevance of community engagement in introducing community-wide change. Sustainability and collaboration may be achieved by engaging the community.³⁹² Participatory research frameworks should be considered for including the community in all stages of the intervention to improve ownership and sustainability.

Finally, local leaders must act to the desires of the community members since the key informants reported that the community is not pleased with the efforts undertaken to battle childhood obesity and is looking forward to extending and upscaling the efforts. As a result, local officials must consider upstream efforts such as policy implementation. Obesity prevention measures have a better chance of being sustainable if law and accountability are a part of the policy implementation process.³⁹³

5.7.2 Findings in relation to the CBSA

The study's second objective was to explore how the estimated readiness and CRM dimensions can improve the understanding of the feasibility of the CBSA to develop childhood obesity prevention interventions within this community. This study showed that current efforts fall short of adequately focused and thorough. As a result, the local community is in the "preplanning" stage for building a comprehensive plan to address childhood obesity. However, this readiness assessment revealed that much more remains to be accomplished in some dimensions to ensure that the community is more ready to effectively take the CBSA for developing childhood obesity prevention interventions.

The dimension of "existing efforts" revealed that most obesity prevention efforts are unsystematic/non-institutional efforts, implemented mainly by one governmental agency and characterised by a lack of collaboration and partnerships. These characteristics of current efforts contradict the features that the CBSA needs, such as developing collaborative partnerships. By way of example, it would make no sense to provide systems intervention to a community where collaborative partnerships among its LAs and other relevant organisations do not exist, or their relationships are not typically solid around community issues such as childhood obesity.

Secondly, the dimensions of "leadership" and "resources" revealed a weakness regarding leadership's concern and support for childhood obesity prevention. As a result, there is a

conflicting priority in addressing childhood obesity within the local community. In addition, findings revealed a weakness in the leadership level in understanding how community members prefer addressing childhood obesity, aligning with the lack of community engagement. Given that much of the success of applying the CBSA to childhood obesity prevention is attributed to the presence of solid and practical leadership,³⁹⁴⁻³⁹⁶ much work needs to be done to improve leadership in this community.

5.7.3 Findings to the international literature

Most research using the CRM for obesity prevention has been undertaken in western nations, making meaningful comparisons difficult. However, the scores found in the current study are higher than those discovered in a comparable study performed in Rome³⁷⁰ but are in line with those previously reported in the UK and the US.^{369,397} Moreover, Makkah's community readiness scores seem higher than those of Latino and religious organisations in South Africa.^{367,398} It is also worth noting that Makkah's community readiness scores are similar to the sole Middle Eastern study utilising the CRM to prevent obesity among primary school children in Iran.³⁷³

5.7.4 Strengths and limitations

This research is unique because it is the first study to apply the CRM model to childhood obesity prevention in SA, a Middle Eastern nation. Research strengths include using the qualitative analysis of interviews, which explains and understands the CRM grading and reveals unique community needs. Another strength is interviewing local key informants who provided solid contextual results. Moreover, the number of interviews exceeded the required range of 4–6. However, recent research examined if increasing the number of interviews alters findings of the CRM and concluded that there was minimal variance in the community readiness scoring after conducting ten interviews.³⁹⁹

However, several limitations to the research must be considered. First, the transcripts were not coded independently by two researchers; nevertheless, if the first scorer was unsure about a specific coding, it was discussed with the other researcher till an agreement was established. Furthermore, selective bias might arise from the purposeful sampling of key informants; nevertheless, this was somewhat alleviated by recruiting several key informants from different sectors. In addition, using the anchoring rating statements to score the CRM interviews has been criticised for allowing too much researcher subjectivity.^{376,400} To overcome this potential issue, two reviewers separately rated the CRM interviews and then aggregated their scores to eliminate any bias. Discussions were held if disagreements emerged among the reviewers. Finally, readers should be highly cautious about generalising study findings to other nations or groups. However, findings of this study might be applied to a nation that shares the same political, cultural and socioeconomic features.

5.8 Conclusion

This CRM assessment suggests that the Makkah community is in "the preparation stage" to address obesity among children under 18. A formative basis has been provided for developing a tailored intervention to fit the community's needs regarding childhood obesity prevention. Efforts should be directed first on gathering and reviewing current information that may be utilised to assist in developing strategies to combat childhood obesity. This may be accomplished by conducting surveys on the prevalence of childhood obesity, providing local data to community organisations and leaders, estimating and communicating the costs of childhood obesity, and hosting public forums to create methods to reduce childhood obesity. Additionally, future plans should consider mechanisms to develop collaborative partnerships to address childhood obesity prevention. Finally, this readiness assessment revealed that much more remains to be accomplished in some dimensions to ensure that the community is ready to effectively take the CBSA for developing childhood obesity prevention interventions.

5.9 Chapter summary and contribution to the thesis

This chapter provided detail on the readiness of the Makkah community to address childhood obesity. Substantial gaps were identified to address the issue due to the lack of funding sustainability. Other highlighted issues included a lack of evaluation of past and current efforts, a lack of engaging other governmental bodies and sectors, and community involvement in designing interventions. In addition, dissatisfaction was found among community members with the role of local leaders in the way of addressing childhood obesity.

This study provided a valuable contribution to achieving the main aim of this thesis. Specifically, this study provided details on the community's readiness to address childhood obesity. In addition, it informed our understanding of the opportunity to take the CBSA to develop childhood obesity prevention interventions within the Saudi community. However, findings were based on the key informants' perspective, and did not clearly indicate factors influencing LAs and relevant organisations to apply that approach. Thus, further investigation (Chapter 6) was required from the decision-makers' perspective in LAs and other relevant organisations.

Chapter 6: The perspective of decision-makers regarding the application of a Systems approach to obesity prevention in Saudi Arabia

6.1 Chapter overview

This chapter continues exploring the feasibility of using the CBSA to develop childhood obesity prevention interventions within the Saudi community. Chapter 5 explored the readiness of the Makkah community to address childhood obesity broadly using the CRM framework. However, this study addressed the fourth objective of this thesis: *What are the decision-makers' perceptions of potential barriers and enablers to developing systems-based interventions within the Saudi community?* A more focused exploration of local DMs' views, using semi-structured interviews, on the feasibility of using the CBSA to develop childhood obesity prevention intervention is needed. The findings presented here are crucial for obtaining insights into barriers and facilitators faced by LAs, thus contributing to our understanding of the feasibility of applying the CBSA within this community and informing recommendations for improving the feasibility.

6.2 Background

Chapter 4 (scoping review) shows that a few empirical studies have tried to apply the systems approach to obesity interventions to replace traditional approaches. However, all these studies were conducted in Western populations. This raises the question of whether it is possible to apply the systems approach established in developed nations such as AUS to culturally and politically different settings such as SA and whether cultural adaptations are required for this new approach to work in those settings.

A recent systematic review of Western studies revealed many barriers to implementing the systems approach in obesity or other areas of public health.³³³ However, applying a systems

approach may be more difficult for non-Western nations considering that the political and cultural contexts in non-Western are usually very different to those in Western countries. For example, one challenge may be achieving cross-border cooperation among LAs and organisations to address health concerns. A Middle Eastern study indicated that cultural and gender barriers impede the ability of varied stakeholders to work together effectively.³⁵⁶ Furthermore, many non-Western nations have a centralised governing system where the central authority has tighter control over LAs. A centralised government might undermine the authority of local governments and may not consider health promotion or illness preventive efforts as politically advantageous.^{357,358} Such obstacles suggest that it is necessary to understand what factors influence non-Western policymakers' intention and ability to successfully apply the systems-based approach to developing public health interventions.

6.3 Aims and objectives

The main aim of this qualitative study was to explore factors that may influence the Saudi government's ability to apply the CBSA for childhood obesity prevention. The following objectives were framed to meet the main aim:

- a) To explore the experience of representatives of LAs, organisations and frontline workers in developing/implementing past and current childhood obesity programmes in Makkah city.
- b) To explore perceived benefits and own roles (in) as well as barriers and enablers to using the CBSA for intervention development.
- c) To explore decision makers' preferred strategies to optimise the processes of organising and running GMB workshops within the Saudi community.

6.4 Research setting

For more details about the research setting, please refer to section 5.4.2 in Chapter 5.

6.5 Methods

6.5.1 Sampling and participants

I compiled a list of LAs and other relevant organisations relevant to this study based on a review of all providers of obesity prevention efforts in the Saudi community. The most important criterion for selecting relevant authorities was their roles and impact on children's obesogenic environment and behaviours. The list was then presented to the supervision team for revision and expansion. Access to LAs and other relevant organisations did not require ethical approval from the local government.

A range of LAs and other relevant organisations were identified to participate in this study. Participants were DMs of LAs and relevant organisations within Makkah city. Purposive sampling was employed to select participants because the researcher had pre-defined recruitment criteria and was looking for specific people with much knowledge about the issue studied.⁴⁰¹ The pre-defined recruitment criteria were: a) working in a local authority or organisation whose roles impact the environments surrounding children; b) a current decision-maker or a frontline worker in a relevant local authority or organisation, or c) a former/current programme leader of a childhood obesity (or obesity in general) control programme. However, in some cases, it was necessary to conduct interviews with a few national leaders whose authorities operate at a national level but also have a role in guiding local authorities, such as public health authorities. These criteria were set to ensure that only agents with the power to make policy/environmental changes within the city for childhood obesity and/or have relevant knowledge/experience in childhood obesity prevention were interviewed.

Snowballing sampling was also used to complement purposive sampling.⁴⁰² Snowballing technique was employed for two reasons: a) it enables identifying more relevant participants who fit the pre-defined criteria, and b) some potential participants may not respond to the recruitment letter due to misunderstanding of the research process or untrust of the researcher. Therefore, participants were asked to recommend potential participants who may give insightful information, and if the recommended individuals met the recruitment criteria, they were contacted for potential participation in this study.

A recruitment letter (Appendix 8) with an overview of the study was emailed to all potential participants/authorities to inquire whether they would participate in this research. As a result, around 75 authorities/organisations/individuals were approached. Those who expressed interest received an information sheet (Appendix 14) and a consent form (Appendix 10). Once a signed consent form was returned to the researcher, the participant was contacted to schedule a mutually convenient time for an interview. The interview was done online through the Zoom application due to the Covid-19 pandemic. The SPS-REC at the University of Bristol approved this research project on 24/03/2021 (Reference: SPS REC/20-21/124) (Appendix 11).

6.5.2 Topic guide development

The semi-structured interview was chosen because it allows the interviewee to probe and ask further questions if necessary while also allowing interviewees to speak about topics of interest.⁴⁰³ The topic guide (Appendix 15) was developed firstly in English and comprised broad topics, questions, and probes to address specified research objectives. First, supervisors who are experts in the systems approach and healthy lifestyles programmes and an expert in qualitative methods reviewed the developed topic guide for relevancy and appropriateness. Then, I translated the topic guide into Arabic, and an independent Arabic researcher reviewed it to ensure its accuracy and that the questions were worded to allow participants to elaborate on their thoughts. In addition, a pilot interview with one potential participant was conducted to

check and optimise the flow and questions of the topic guide. As a result, the topic guide was very slightly modified based on the pilot. Modifications included a few words changing and changing the ways of asking and explaining. The final version of the topic guide is summarised in Table 6-1.

Table 6-1: A summary of the topic guide for decision-makers interviews

Steps	Aims	Questions
Introduction	<ol style="list-style-type: none"> 1. Welcoming and seeking permission to audio record the interview. 2. Answering any questions the participant has regarding PIS and consent form. 	
Topic 1	Personal knowledge and experience of childhood obesity programmes	<ol style="list-style-type: none"> 1. What are your thoughts on childhood obesity in general? 2. Have you had any experiences with delivering a childhood obesity programme? 3. How important an issue do you think childhood obesity is?
Topic 2	Previous organisational experience in preventing childhood obesity	<ol style="list-style-type: none"> 1. Where is childhood obesity prevention situated in your priority list (pyramid)? 2. Are your local authority/organisation working, or have you worked with any other organisations for tackling childhood obesity? 3. What is your authority role in that programme? Were there any successes or challenges you can recall? Why do you think this is the case?
Topic 3	Perceived barriers, facilitators to, as well as perceived own roles in developing systems-based childhood obesity prevention interventions using GMB	<ol style="list-style-type: none"> 1. What are your views on the systems-based approach? 2. What would be the potential barriers to applying this new approach to developing childhood obesity interventions in your community? 3. What would be the potential facilitators to applying this new approach to developing childhood obesity interventions in your community? 4. Is your organisation/authority willing to take part in developing systems-based intervention using this approach? What role can your organisation/local authority play in preventing childhood obesity?
Topic 4	Preferred strategies for organising and running GMB workshops	<ol style="list-style-type: none"> 1. What do you think are the best strategies to organise a GMB workshop within the Saudi community?

		2. What do you think are the best strategies to run a GMB workshop within the Saudi community?
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The topic guide is focused on several issues: 1) personal knowledge and experience of childhood obesity programmes; 2) previous organisational experience in preventing childhood obesity; 3) perceived barriers, facilitators to as well as perceived own roles in developing community systems-based childhood obesity prevention interventions using GMB, and 4) preferred strategies for organising and running GMB workshops. The core questions were identical for all participants, but unique probes were provided for participants based on their authority's position in the community. In addition, prompts and probes were used throughout the interviews to stimulate discussion.

6.5.3 Data collection

Interviews were conducted with DMs from diverse sectors, including LAs, private organisations, and NPOs. Most participants joined the interviews in a quiet and familiar place, such as work and home offices. Interviews lasted between 30 and 120 minutes, with an average of 45 minutes. All interviews were conducted in Arabic by the same researcher (myself), a native Arabic speaker with training and experience in qualitative research.

Prior to each interview, it was explained to each participant that they were free to terminate the interview at any time for any reason and that their participation in the research was voluntary. However, once data analysis has begun, data cannot be retracted. Signed informed consents were obtained before each interview. Interviews were conducted online and audio recorded. Interviews were transcribed verbatim by the researcher (myself) using NVivo transcription paid service, and then all transcripts were rechecked against audio recordings. All transcripts were anonymised to protect participants' identities. After each interview, I summarised the key

points that the participants supplied and requested them to remark on the correctness of the summary and offer clarification or add any new information to maximise the data's credibility.

6.5.4 The trustworthiness of the data collection process

For more details on the trustworthiness of the data collection process, please refer to section 5.4.5.2 in Chapter 5.

6.5.5 Data analysis

Data analysis was conducted using the original language of the interviews (Arabic). It is recommended to carry out the analysis of transcripts in their original language since translating each transcript into English may influence the data and, thus, the trustworthiness of the findings.^{387,388} It is time-consuming and costly to translate an interview since a good translation requires a back-and-forth translation to verify the translation. Moreover, some expressions or terms specific to the Arabian (Saudi) culture could be lost during translation. Therefore, analysis using the transcripts' original language is suggested to avoid misinterpreting interviewees' responses.³⁸⁷ However, the identified themes and the illustrative phrases were translated into English by myself and checked by a bilingual researcher.

Thematic analysis (TA) was used to discover patterns within the collected data.³⁸⁹ The TA was chosen because it enables the researcher to uncover common themes or patterns in the collected data and choose how to engage with it.⁴⁰⁴ The inductive approach was chosen as it stimulates the emergence of themes solely based on the collected data rather than having to fit into a pre-selected framework or theory.^{389,405} The six phases of TA are presented under the following subsections.

6.5.5.1 Data familiarisation

Prior to this stage, re-listening to the audio recordings in the transcription process ensured no information was missed and helped with data familiarisation. At this stage, each interview transcript was carefully read more than once, and some comments were added, including initial thoughts and possible patterns. Frequently recurrent or interesting phrases were also highlighted.

6.5.5.2 Generating initial codes

This stage involved creating codes that indicate a critical feature of the data that may help address the research objectives. Initially, I selected the four richest transcripts and extensively studied them. The initial codes that shared the same features or meanings were grouped into preliminary themes and subthemes. After discussions with supervisors, these preliminary themes were developed into a coding scheme which was applied to the remaining transcripts in a constantly evolved manner. Qualitative data analysis software, such as NVivo, could not be utilised during data analysis since they are incapable of dealing with Arabic. Instead, transcriptions were manually coded. Paper copies of transcripts were used during the coding process. Specific words, phrases or paragraphs of the text that included information relevant to a given point were labelled, and initial codes were written next to them. Then, initial codes and the translated supporting quotes were entered into a spreadsheet document in a tabular style. The translation of supporting quotes was done by myself to ensure the accuracy of the contextual and cultural implications.

6.5.5.3 Searching themes

While the collected data were coded, a constant comparison was used to revise the initial coding scheme. It was an iterative process that included ongoing discussions among supervisors.

6.5.5.4 Reviewing and Defining themes

This stage involved reading, examining, revising and expanding the preliminary themes established through the previous stages. The primary goal was to transform the descriptive organisation and naming of the current themes into an interpretative presentation of the results. Meetings with the supervisors led to the descriptive themes being re-clustered and renamed so that the results could be used by policymakers and other researchers more easily.

6.5.5.5 Writing up

During this stage, it was ensured that the writing was informed by the above quality assessment principles (trustworthiness) and the commonly used qualitative reporting guidance⁴⁰⁶. Original codes were included to illustrate each theme.

6.6 Results

6.6.1 Characteristics of the study participants

Eighteen interviews were conducted with DMs representing various LAs or organisations. No new information emerged from the 18th interview, indicating data saturation,⁴⁰³ so recruitment was ended. Most interviewees (Table 6-2) worked in governmental bodies. Several private organisations declined to participate in the study and stated that they do not have current or previous participation in childhood obesity prevention

Table 6-2: Summary of the characteristics of the study participants

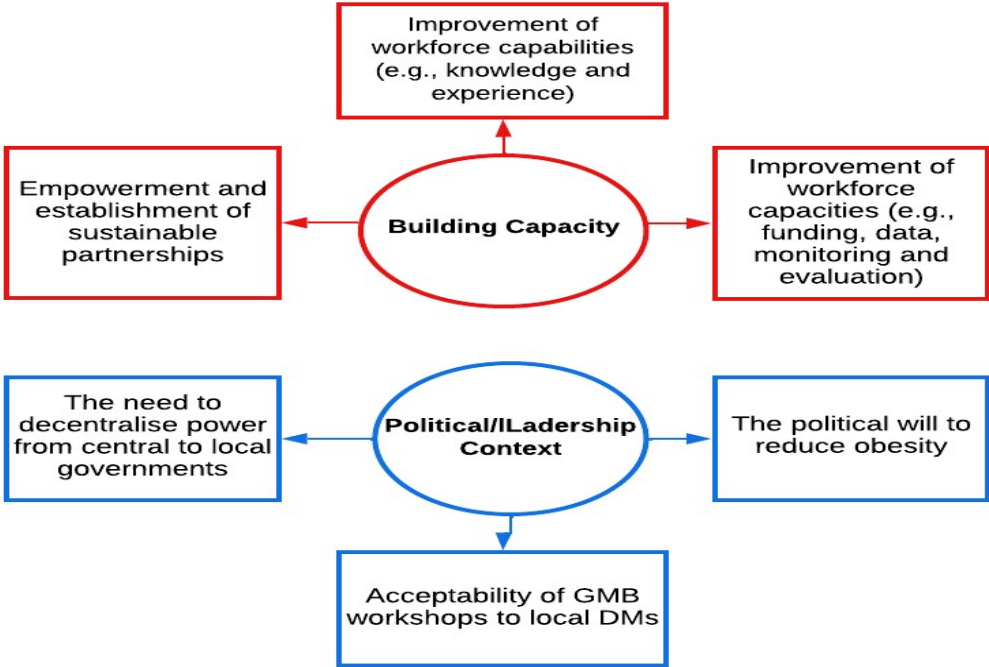
Authority/Programme name	Authority type	NO. of participants	Level	Position	Gender
School Health Affairs Department	Governmental	3	Local	2 seniors 1 frontline worker	1M* 2F*
Early Childhood Department	Governmental	2	Local	Seniors	F
Health Research Institute	Governmental	1	Local	Senior	M
Childcare Association	Non-profit	1	Local	Deputy	F
Authority of Public health	Governmental	1	National	Senior	2M 1F
School Sport Federation	Governmental	1	National	Senior	M
Health Programs and Chronic Diseases Department	Governmental	2	National and Local	Seniors	M
Healthy Food Department	Governmental	1	Local	Senior	M
National Nutrition Committee	Governmental	1	Local	Senior	M
Public Health Department	Governmental	1	Local	Frontline worker	F
Food Industry	Private	1	National	Senior	F
National Obesity Control Program	Governmental	1	National	Senior	F
Department of City Planning	Governmental	1	Local	Senior	M
School Obesity Control Programme	Governmental	1	Local	Senior	F
Total	12= governmental bodies 1= private 1= non-profit.	18	13= local 5= national	15= seniors 2=frontline workers 1=deputy	10 F 8 M

*M= Male; *F= Female

6.6.2 Emerged themes

Factors influencing the ability of the Saudi government to apply the CBSA to the development of childhood obesity are presented under two core themes: 1) building capacity and 2) political/leadership context. The following sections describe the core and finer themes (Figure 6-1) with illustrative quotes.

Figure 6-1: The final core and finer themes



6.6.2.1 Core theme 1: Building capacity

This theme includes three subthemes: 1) improved workforce capacities, 2) improved workforce capabilities, and 3) empowerment and establishment of sustainable partnerships.

6.6.2.1.1 Finer theme 1: Improvement of workforce capacities

DMs participating in this study discussed several issues related to the capacity of LAs and other relevant organisations.

Notably, the lack and/or limited funding was reported as a main barrier to initiating efforts to combat childhood obesity or other public health issues. However, a proposal had been sent to the central government to start a public health fund that can enable LAs to initiate their efforts regarding public health issues, including childhood obesity:

'The only obstacle we have is the budget' (P16, Male from Department of City Planning)

'The weakest point is also the budget... Other authorities say you want me to do this. Where is the budget? Who is going to pay for it? We cannot oblige them without giving them a budget... they say we do not have enough budget to implement this agenda. This is the biggest challenge we have today.... We have put forward a proposal to establish a public health fund.' (P15, female from the Authority of Public health (National))

Furthermore, many DMs pointed out the lack of data on childhood in general or childhood obesity locally or nationally:

'There is no data on childhood obesity' (P17-male from the National Nutrition Committee)

'Unfortunately, we have a lack of data and research on children in the country' (P10, female from Childcare Association)

'Unfortunately, the sources and data we have are somewhat scarce.'

(P2, male from the Healthy Food Department)

Notably, several DMs reported a severe weakness in the monitoring and evaluation capacities. As a result, some DMs revealed the need to improve authorities' capacity in monitoring and evaluating:

'There should be a continuous monitoring and following-up' (P11, male from the School Sports Federation)

'Our weakest point is monitoring and evaluation... We have a problem in collecting data.... and assessing the impact... We do workshops... but after that, did we follow up with other authorities? Did we see what they are doing? what they achieved?' (P15, female from the Authority of Public health (National))

'There [LAs] must be monitoring.... And evaluation, a genuine evaluation.' (P18, female from the School Obesity Control Programme)

Furthermore, a decision-maker in a national committee whose role is to provide recommendations and scientific opinions regarding the nutritional and health status of the whole country revealed a lack of plans and public health experts in leading non-communicable prevention programmes:

'There is no plan to control NCDs, especially for childhood obesity, for the next three or five years...Programme leaders are physicians who talk about conditions and diseases... Obesity efforts in the country are Reactive, not proactive... They do not belong to the

public health sector' (P17-male from the National Nutrition Committee)

Furthermore, few DMs reported a low level of readiness and willingness among LAs and other relevant organisations to address childhood obesity:

'Applying this approach [SAP], meaning there will be a collision with the governmental agencies, which I call them the old fashion ones such as [Names were masked] also, the willingness of authorities, key players, do not have the readiness and willing...they all will say this [childhood obesity prevention] is not our task' (P17-male from the National Nutrition Committee)

Some DMs attributed the limited readiness and willingness among authorities to the lack of a clear demarcation of roles and responsibilities. The same roles are assigned to more than one authority. So, they expressed a need for a clear demarcation of roles and responsibilities among LAs:

'They must have a definition of the tasks that are required from them' (P3, female from Early Childhood Department)

'Roles in obesity prevention need to be specified... More than one party has the same roles' (P4, male from Health Research Institute)

'For example, the Ministry of Sports have to do this. the Ministry of Education must do this.... The private sector must do these things' (P11, male from the School Sports Federation)

'Childhood obesity will only be resolved when the stakeholders sit down together...and demarcate the roles clearly' (P1, female from School Health Affairs Department)

All DMs recognised the importance of childhood obesity prevention. However, there is a priority conflict among authorities on tackling childhood obesity. Some DMs revealed a high priority to combating childhood obesity in their bodies, while others revealed that addressing obesity among children does not exist on the list of priorities in their authorities:

'It [childhood obesity prevention] is important, necessary and first priority' (P16, Male from Department of City Planning)

'It [childhood obesity prevention] is part of our work but not a priority' (P11, male from the School Sports Federation)

'I cannot say it [childhood obesity prevention] is a high priority.' (P10, female from Childcare Association)

6.6.2.2 Finer theme 2: Improvement of workforce capabilities

DMs participating in this study also discussed several issues related to the capabilities of the local workforce.

Nearly all DMs reported a lack of experience among non-health authorities and organisations (those that are not set up primarily to address public health issues) in designing or delivering childhood obesity prevention programmes or any related programmes:

'We found some governmental agencies, such as [names were masked], do not provide any efforts about childhood obesity'. (P1, female from School Health Affairs Department)

'We do nothing about childhood obesity' (P9, female from the Early Childhood Department)

'We do not have any experiences related to childhood obesity prevention' (P16, Male from Department of City Planning)

Additionally, nearly all DMs reported a lack of experience in participatory and systems thinking approaches, such as the GMB workshops to prevent or manage childhood obesity or any other NCDs:

'I participated with others...regarding addressing obesity, but they are not based on systems work' (P11, male from the School Sports Federation)

'No, I have never participated in systems work with other bodies' (P14, female from the National Obesity Control Programme)

'Never participated in systems thinking approach' (P7, male from Health Programs and Chronic Diseases Department (national))

Importantly, few DMs indicated that collaboration across sectors does happen but only at the implementation stage, not the development stage:

'When legislation is being issued, all sectors must participate, whether from the government sectors, the private sector and other bodies to express an opinion.' (P2, male from the Healthy Food Department)

'We do not get them (other authorities) to think with us. We are preparing the agenda, preparing all matters, thinking about the

issue, and discovering what is required of them in each authority'

(P15, female from the Authority of Public health (National))

Some DMs revealed other challenges regarding the level of knowledge regarding obesity prevention among LAs and suggested education to local DMs before initiating any prevention approach:

'You may get shocked by the level of knowledge among authorities regarding childhood obesity prevention...Their knowledge is terrible' (P17-male from the National Nutrition Committee)

'It is necessary to educate the decision-makers before starting this approach [SAP]' (P13, male from Public Health Department)

A decision-maker in the Saudi Authority of Public Health reported the need to raise awareness of DMs regarding childhood obesity and its burden:

'Decision-makers must feel the burden of the problem. Importantly, the economic cost... There must be raising awareness among all authorities regarding childhood obesity before starting this approach [SAP] ...they must know that addressing obesity among children means reducing economic burdens on the country... The first thing is to educate each authority and what benefits they can get when reducing obesity'
(P15, female from the Authority of Public health (National))

6.6.2.2.1 Finer theme 3: Empowerment and establishment of sustainable partnerships

Most DMs indicated a lack of a role for the private sector and NPOs in addressing childhood obesity:

'The governmental agencies are the ones to decide on the matter [childhood obesity prevention]. The private sector has nothing to do at all' (P10, female from Childcare Association)

'Mostly the private sector is not influential, non-profit organisations are also not very influential' (P8, male from Health Programs and Chronic Diseases Department (local))

Importantly, this lack of engaging the private sector could be a deliberate tendency by the government, as revealed by a decision-maker, and also attributed to the complicated procedure of starting a partnership:

'There is a tendency to reduce partnerships with the private sector in health programs' (P1, female from School Health Affairs Department)

'To start a partnership with the private sector... there are lengthy and difficult procedures to go through'. (P3, female from Early Childhood Department)

Furthermore, a decision-maker in one of the largest food industries pointed out that the legislation established by the Saudi authorities regarding the improvement of food products is stringent and difficult to achieve:

'The legislation established by [names were masked] is tough to achieve. They want us to achieve in three years what the West has achieved in ten years, which is difficult'. (P12, female from a private company in the food industry)

Local DMs expressed the need to empower private sectors and food industries to participate in childhood obesity prevention, and they asked for demarcation of roles for each party:

'Now it is necessary to work with other parties and benefit from each other' (P1, female from School Health Affairs Department)

'All governmental bodies, private and non-profit organisations have a role. The question here is how much percentage of the role of each party. And if they share the same roles which party have more percentage' (P4, male from Health Research Institute)

'Each party should know its roles' (P7, male from Health Programs and Chronic Diseases Department (National))

Lack of communication and cooperation among LAs and other relevant organisations was reported as a reason for the failure of past efforts to address childhood obesity. DMs identified that establishing effective and long-term communication and coordination across boundaries is required:

'There are programs to address obesity provided by many authorities. Unfortunately, they failed because there is no communication among authorities.' (P17-male from the National Nutrition Committee)

'The first requirement is coordination and communication' (P3, female from Early Childhood Department)

'Communication is the biggest obstacle... communicating among authorities will not be easy.' (P14, female from the National Obesity Control Programme)

'We should start an effective communication..... We do not have a long-term working relationship.' (P15, female from the Authority of Public health (National))

6.6.2.3 Core theme 2: Political and leadership context

Three finer themes sit under this core theme: 1) the political will to reduce obesity, 2) the need to decentralise power from central to a local authority, and 3) the acceptability of the GMB workshops among local decision-makers.

6.6.2.3.1 Finer theme 1: The political will to reduce obesity

Notably, all DMs pointed out positively the political will to reduce obesity at a national level through implementing several national strategies and policies:

'Banning soft drinks in schools and government facilities' (P17-male from the National Nutrition Committee)

'A tax was imposed on soft drinks... Another tax on sweetened drinks... Displays calories and labels in restaurants... Obligating food manufacturers to put food labels' (P15, female from the Authority of Public health (National))

'Girls are now offered physical education in schools.... Female sports clubs are now licensed and supported.' (P7, male from Health Programs and Chronic Diseases Department (national))

In addition, DMs revealed that there would be some upcoming positive movements that demonstrate a high /increased political will:

'Now we are also working on legislation that has not yet been released, which is controlling advertisements targeting children...banning toys in children's meals...banning unhealthy snacks from the check out in stores' (P7, male from Health Programs and Chronic Diseases Department (national))

'Any advertisement directed to children is supposed to take approval from [names were masked] and should be an option with high nutritional value' (P17-male from the National Nutrition Committee)

'Focusing on walking tracks... and bicycle tracks, and focusing on parks and gardens, for example, there should be walking tracks and fitness equipment in parks... We have changed all the parks designs' (P16, Male from Department of City Planning)

Moreover, some DMs revealed the creation and dismantling of new departments within authorities to combat obesity:

'We have created a department within kindergartens to take care of all obesity matters' (P3, female from Early Childhood Department)

'Previously, all health programs were within the MOH.... Creating sub bodies from the ministry, one of which was the National Center for Disease Prevention and Control' (P15, female from the Authority of Public health (National))

'We established a department called the Community Services, and all municipalities now have this department that deals with such matters [childhood obesity prevention]' (P16, Male from Department of City Planning)

Furthermore, several non-compulsory pledges have been signed with major food industries, and a national award has been announced for those food industries that applied the standards set in the healthy food strategy:

'We signed agreements with the major companies globally to reduce the sugar content... salt...trans-fat... There is a gold, bronze and silver award for those who applied the standards set in the healthy food strategy to reduce sugar, salt and fat' (P17-male from the National Nutrition Committee)

However, some DMs revealed that most of the efforts at the national level focus more on adult obesity than children. A future focusing on childhood obesity would be done:

'Currently, we mostly focus on obesity among adults.' (P7, male from Health Programs and Chronic Diseases Department (national))

'For childhood obesity, we have not done anything yet... but we have taken simple initiatives such as developing guidelines for healthy food for this age (0-18 years) ... Focus on this age group and developing

appropriate programs are among the plans that we are developing'

(P15, female from the Authority of Public Health (National))

Furthermore, local DMs support integrative responsibility to address childhood obesity in the community. Several local DMs advocate for joint measures and efforts and the elimination of individual work and responsibility in the fight against childhood obesity:

'I hope integral responsibility is applied to childhood obesity prevention'

(P6, male from School Health Affairs Department)

'Obesity is complicated, it is not the work of one authority, and it is everyone's responsibility' (P15, female from the Authority of Public health (National))

'One hand does not clap; most authorities must participate in the fight against childhood obesity.' (P2, male from the Healthy Food Department)

6.6.2.3.2 Finer theme 2: The need to decentralise power from central to local government

Several DMs identified several obstacles impeding their efforts to prevent childhood obesity. A high bureaucracy (top-down hierarchy) was reported as an obstacle among many authorities:

'The obstacle is the bureaucracy... the problem is that it takes a long time.... Procedures and administrative matters take a long time' (P3, female from Early Childhood Department)

'Our work style is still old. Approvals must be obtained from the central centre' (P1, female from School Health Affairs Department)

Additionally, few DMs revealed that their authorities lack the freedom to sign contracts:

'There must be approval from the top to conclude any agreements or cooperation with other parties.' (P14, female from the National Obesity Control Programme)

'There is a problem with Partnerships. It is a complicated process... we have to get an approval' (P3, female from Early Childhood Department)

'I have to take a permit, and the permit takes time... which means a long way' (P9, female from the Early Childhood Department)

Furthermore, some DMs reported that their authority's role is limited only to implementing the established programs that they receive from the central government:

'Programs come from the ministry. We just deliver them.' (P3, female from Early Childhood Department)

'The ministry designs the program, and we just implement it. We do not have any roles in designing the programmes and cannot change it or tailor it' (P1, female from School Health Affairs Department)

6.6.2.3.3 Finer theme 3: The acceptability of GMB workshops to local decision-makers

Numerous concerns regarding the operational aspects of the GMB workshops within the Saudi community were identified. These considerations include support from decision-makers, willingness to take part, obstacles, and facilitators to conduct the GMB workshops.

Most local DMs expressed their support for conducting the GMB workshops and its applicability within the Saudi community and believed that this kind of work is a need:

'It is [GMB workshops] a good model and brings all the authorities together' (P11, male from the School Sports Federation)

'We support using these new mechanisms and methods. This [GMB workshops] is what we need.' (P15, female from the Authority of Public health (National))

Moreover, most DMs expressed their willingness to participate in the GMB workshops:

'Very welcome to participate in such workshops [GMB workshops] and will be supportive' (P6, male from School Health Affairs Department)

'We will definitely take part in a workshop like this (GMB workshops).'
(P9, female from the Early Childhood Department)

'I am ready to participate in it [GMB workshops].' (P3, female from Early Childhood Department)

However, some obstacles were identified. A major perceived obstacle is that LAs cannot participate without getting approval from the central government:

'An approval from the top is needed to start and participate in a workshop like this [GMB workshops]' (P11, male from the School Sports Federation)

"We do not have any problem participating if we get directions from the ministry.... There must be directives from higher authorities to take part in workshops' (P8, male from Health Programs and Chronic Diseases Department (national))

'The obstacle to doing this workshop [GMB workshops] is getting and delaying approvals.' (P17-male from the National Nutrition Committee)

Moreover, some DMs identified another obstacle that is related to the power of attendees in the workshop:

'The third obstacle may be the nomination of individuals who are not considered decision makers' (P17-male from the National Nutrition Committee)

'We do many workshops and always have representatives from all authorities. Unfortunately, the decision-makers who have the power to change do not attend' (P10, female from Childcare Association)

Moreover, nearly all DMs reported that there are no cultural issues to consider before applying the GMB approach:

'I do not think at the moment it is ever a problem...there are no cultural or gender issues at these days' (P15, female from the Authority of Public Health (National))

'I do not see a cultural problem at present. The situation has changed. mixing is very important, and segregation is the problem' (P17-male from the National Nutrition Committee)

However, very few female DMs suggested conducting a segregation workshop:

"If it is possible to do two separate workshops, one for males and one for females, it is better because some women do not prefer to attend with men"

in the same workshop” (P5, female from the School Health Affairs Department)

Most DMs did not reveal any issues related to the workshop process (key activities). However, it was found that understanding the CLD might be an issue:

‘They [local decision-makers] may not understand this model [causal loop diagram]’ (P15, female from the Authority of Public health (National))

Finally, a few DMs expressed that workshops invitations should be sent only to relevant authorities and carefully selected attendees:

‘The number must be limited to authorities whose their roles impact children’s environment such as [names were masked], and all of the attendees have the power to change” (P1, female from School Health Affairs Department)

6.7 Discussion

The following subsections summarise the key findings of this study and compare findings with the international literature. The limitations and strengths of the current study are also discussed.

6.7.1 Key findings summary

This study aimed to explore factors that may influence or facilitate the Saudi government’s ability to apply the CBSA to developing childhood obesity prevention interventions from decision-makers' perspectives in LAs and relevant organisations. Two emerging themes help describe the feasibility of applying this approach: 1) building capacity and 2) political and leadership context. These findings highlighted several barriers hindering the application of the

CBSA to developing childhood obesity prevention interventions and presented a few facilitators for improving the feasibility of using this approach.

Several barriers were identified related to the capacity of LAs and other relevant organisations. These barriers include a lack of public health experts, a limited/lack of financial resources and severe weakness in evaluation and monitoring capacities. These findings were also identified in Chapter 5 as limitations of current and past efforts addressing childhood obesity in the local community. Furthermore, several barriers were identified related to the capabilities of LAs, such as a lack of authority and personal experience and knowledge in childhood obesity prevention in general and a systems-based approach in particular. Moreover, findings revealed overlapping roles and responsibilities among LAs. Finding related to overlapping responsibilities was also identified in Chapter 5 as a limitation of current/past efforts. In addition, this study reported a lack of collaborative work (communication and coordination), a lack of engaging other parties, such as the private sector, and a lack of long-term partnerships with other authorities or bodies. These findings are also supported by the study in Chapter 5, in which key informants reported a lack of collaborative work and called for establishing a partnership and a long-term relationship with other sectors to address childhood obesity in the local community.

Some facilitators related to the political and leadership context were also identified. These facilitators include the political will to reduce obesity at the national level through implementing several national policies, such as taxation and creating and dismantling new departments within governmental authorities to improve community health. Moreover, findings found the support of local DMs about the integrative responsibility to address childhood obesity through a systems-based approach. In addition, findings revealed no major

cultural issues to consider before applying the GMB approach. However, a high bureaucracy and organisational structure were also identified among LAs and other organisations.

6.7.2 Findings in relation to the international literature

This study is the first of its kind, making meaningful comparisons challenging. However, a survey of health policymakers in Eastern Mediterranean countries to explore factors that may hinder using the systems approach supports the findings of this study. The survey reported a lack of knowledge and experience in systems approach among policymakers. It concluded a need to build capacity and awareness due to the minimal experience and capacity to apply a systems approach.⁴⁰⁷ Moreover, a mixed-methods UK study investigating the elements of the systems approach to community-centred public health reported that strengthening capacity and capability, including building the workforce's knowledge and skills, is one of the main elements of using the systems approach in public health.⁴⁰⁸ Moreover, the successful application of Healthy Together Victoria (HTV), which adopted the CBSA to tackle obesity in Victoria, AUS, was attributed to building capacity and the capability of an inexperienced workforce.⁴⁰⁹ In the HTV, workforce development was considered fundamental to shifting a project-oriented workforce into one that was capable of considering systems (systems thinkers).⁴¹⁰

Capacity and capability building among the prevention workforce is identified as a need to use a CBSA.⁴¹¹ Insufficient capacity was identified as a significant obstacle to a systems-oriented approach.⁴¹² So, the two programmes, including WHOSTOP²³³ and RESPOND³⁴⁷, unique programmes that have applied a comprehensive systems approach to childhood obesity prevention, have focused firstly on building capacity across a broader range of stakeholders. The WHOSTOP has been evaluated and shown to substantially impact children's takeout food intake and quality of life.³⁴⁹ Recently, workforce capacity and capability were identified as

significant elements in a model representing what makes obesity prevention using a systems-based approach work. The model was based on researchers' experience in more than 120 communities through their work.⁴¹³

A major issue related to the capacity of LAs is the lack of or limited funding for childhood obesity prevention in the country, which is also supported by the finding of the World Obesity Federation about childhood obesity prevention in SA.⁵¹ This lack of or limited funding has led to fragmented and weak childhood obesity prevention interventions. Therefore, the Saudis need to find ways to finance the fight against childhood obesity and establish a public health fund that might be one of the solutions, as one of the DMs explained. Furthermore, another issue is the scarcity of data on childhood in general or childhood obesity which is also reported in the Arab and Saudi literature.⁴¹⁴⁻⁴¹⁶ This lack of data at the national or local level may hamper the implementation of evidence-based childhood obesity prevention interventions. Therefore, there is a need for data on prevalence at the local level and a description of determinants of obesity among Saudi children, including upstream determinants.

The Saudis need to focus on building capacity among LAs by increasing funding, constructing national and local data, and building knowledge of the system through developing a partnership, exchanging knowledge, and carrying out a needs assessment. Furthermore, there should be a focus on developing the capabilities of the local force through investing, providing and supporting participatory and systems thinking approaches. Moreover, non-profit and community-based- organisations need to be empowered and given a role in addressing childhood obesity.

Findings revealed a severe lack of evaluation and monitoring capacity among LAs. However, evaluating systems interventions is challenging,³³³ evaluation is recommended to inform decision-making. The evaluation can also answer certain questions regarding the type of

programmes/policies needed, the impact of those programmes/policies, and/or what to do next.⁴¹⁷ Given the Saudi case, focusing on the capacity building should also include the development of monitoring and evaluation capacity, at least at the local level, to sustain the ability of the community to evaluate their local initiatives. Furthermore, evaluation and surveillance resources must be available for all relevant bodies, including academia.

The findings of this study concerning the lack of partnership, lack of collaboration, poor coordination, and communications among governmental authorities are also supported by the WHO Regional Office for the Eastern Mediterranean (WHO-EM) findings.⁴¹⁸ The importance of partnership, collaboration, coordination and communication when applying the CBSA is documented elsewhere.^{1,413} Obesity prevention efforts in this country are often uncoordinated, siloed and fragmented, despite the trend toward collaborative practice to handle complex issues such as obesity. Considering the nature of the systems-based approach that relies on collaborative work among all key players, these areas need much improvement to inform the feasibility of applying the CBSA in this country.

Decentralising power from central to local (localism) is recommended within the Saudi community to solve childhood obesity. Centralising power may impede progress and restrict the authority's ability to shape decisions.^{419,420} Decentralised power could be considered preferable to prevent childhood obesity. Decentralisation may help LAs assess their needs and establish partnerships and collaboration with other agencies based on the needs of their community. However, a rush decentralisation of power is not advocated since it often leads to weak, disorganised, ineffective, and understaffed LAs.^{205,421}

One of the promising points identified in this study that may enhance the use of the CBSA to address childhood obesity is the political will to reduce obesity at the national level. This political will appears in implementing nutrition policies, including taxation and regulations.

However, it is still unclear to what extent the positive improvements in obesity rates may be attributable primarily to the policies alone.⁴²² Adopting policies alone may not be sufficient to reduce overweight/obesity rates. Although nutrition policy is considered one component to reduce obesity prevalence, other components, such as the built environment, are also important. Given the Saudi case, LAs need to work with other public and private stakeholders to develop and enact other policies. Well-demarcated roles and responsibilities among local actors and partners in childhood obesity prevention are required. There is excellent value in engaging local communities to explore their views to ensure that policies and design measures respond to their needs, resulting in better outcomes.

GMB is a system dynamic method that originated from System Science and appeared acceptable and supported within the Saudi community. However, this study found that some efforts must be made before organising and running GMB workshops within the Saudi community. There is a need to raise relevant knowledge among local actors on the dynamic nature of obesity, obesity prevention at the community level, authorities' roles and responsibilities, resources, sustainability and intervention factors. A low level of understanding of these factors may obstruct the spread of an evidence-based intervention across the community. It may also lead to a reluctance to participate in the workshop.

Moreover, administrative decentralisation of power from the national to the local level is needed. DMs in this study revealed difficulty in participating in workshops with other bodies without permission from the central authority. Such decentralisation may solve these issues and have significant benefits because LAs may understand and react to citizens' demands more effectively than a central authority. Furthermore, this study revealed a very positive cultural development regarding gender segregation which moves upending a major hallmark of obligatory conservative restrictions that had been in place for decades. However, a pilot of

GMB workshops (Chapter 7) was recommended to test and identify the most feasible and efficient recruitment strategies and the most culturally appropriate way to run a GMB workshop in this community.

6.7.3 Strengths and limitations

This study is the first of its kind, to the best of the author's knowledge, to explore factors from a government perspective that may hinder the application of CBSA to the development of childhood obesity prevention interventions. DMs represented a variety of local/national authorities and other relevant organisations, thereby offering a wide range of perspectives and enabling data saturation to be achieved. A significant strength is related to the question itself; examining the feasibility of using the CBSA in a particular society is seldom investigated. As such, significance lies in that the results will be of relevance to other groups with similar situations to the Saudi population. This generalisability might be feasible because of a robust interview sample and the inclusion of representatives from all key authorities and organisations.

This study's weakness is related to recruitment. This study recruited a few participants from the private sector, although efforts were made. Unfortunately, most of the private sector did not respond or perceive that they have no role in combating obesity in the country. Moreover, a further weakness relies on qualitative interviews, which are susceptible to bias from the interviewees and the researcher. The researcher received training in interviewing techniques, and interview procedures and scripts were developed and applied to minimise these possible risks. Several precautions have been taken to ensure the data's trustworthiness, and a transparent and comprehensive description of the methods was provided. However, despite the detailed description of the data analysis process and frequent discussions with supervisors, only one researcher (a native Arabic) actually conducted the analysis.

6.8 Conclusion

Local leaders favour and support using the CBSA to address childhood obesity in the local community. However, this study demonstrates that LAs and other relevant organisations are not in a strong position in terms of readiness and willingness to start applying the CBSA to obesity. More work is needed to improve readiness and willingness among relevant stakeholders. Local DMs are recommended to build the CBSA workforce, including knowledge, skills, experience, and partnership. Moreover, there is a need to establish monitoring and surveillance systems for childhood obesity. Furthermore, some work relies on central authorities, such as decentralising power to LAs to ensure efforts meet citizens' demands more effectively. Given Saudi's unique culture and political system, future research is recommended to conduct more research on applying the CBSA in obesity prevention.

6.9 Chapter summary and contribution to the thesis

This chapter presented factors that influenced LAs to take the CBSA to childhood obesity prevention. Generally, influencing factors are related to a) the low and/or limited workforce capacities, b) the lack of systems thinking capabilities, c) the lack of partnerships, d) limited collaboration with other governmental authorities, and finally, e) the centralised power. In addition, a political will to reduce obesity at the national level was also highlighted. Moreover, the GMB approach was also accepted from the perspective of local decision-makers, and cultural norms that may influence the GMB approach were also discussed.

The findings of this study provide a more detailed picture of factors influencing LAs and relevant organisations to apply the CBSA to the development of childhood obesity within the Saudi community. In addition, integrating findings with other studies in this PhD provide a detailed assessment of the feasibility of using CBSA within the Saudi community. This study

also contributed to informing the design of the virtual GMB study (chapter 7), such as the recruitment and composition of workshop participants and any cultural norms that may influence the running and organising of the GMB approach. However, this study did not provide detailed information on the most appropriate way to conduct GMB workshops within the Saudi community. Thus, a further investigation of the most appropriate way to conduct GMB workshops within the Saudi community was required. Therefore, the next chapter presents a pilot study that explored the most appropriate way to conduct GMB workshops within the Saudi community.

Chapter 7: The feasibility of applying the Group Model Building within the Saudi community

7.1 Chapter overview

This chapter reports a study that explored the feasibility of using the CBSA to develop childhood obesity prevention interventions. However, its focus differs from previous chapters. This study addressed the fifth objective of this thesis: *What is the most feasible and appropriate way to organise and conduct 'GMB' workshops within the Saudi community?* by conducting a pilot study that involved organising and running a GMB workshop within the Saudi community and reflecting on the operational process and outputs. This chapter starts by detailing GMB as a System Dynamics tool, its previous uses, usefulness and limitations. Findings are expected to inform the organisation and running of future GMB workshops within the Saudi community and other similar settings.

7.2 Introduction

Chapter 2 (literature review) briefly describes the GMB workshop. The following sections introduce the GMB approach, its previous uses, usefulness and limitations.

7.2.1 What is GMB?

It is a system dynamics means that provides a workshop structure to engage diverse stakeholders in collective activities to create a dynamic system model known as a CLD.²⁴⁰ The developed CLD is considered a reflection of the mental models of GMB participants since they provide their input directly into the diagram.⁴²³ CLDs provide participants with a visual representation of a problem, enabling them to recognise their contributions to the model-building process and the areas in which they may affect systemic change. It includes facts and

essential knowledge and how the working parts relate to each other and reflects their values and beliefs in a subject area.⁴²⁴

The notion of involving stakeholders in model development dates back to the 1980s.⁴²⁵ However, no specific procedure for involving stakeholders in model development was defined. In 2012, a formal report on GMB scripts and techniques was issued by Hovmand and colleagues.⁴²⁶ Their paper revolutionised dynamic system modelling by describing how to involve stakeholders and establishing a common framework for GMBs.

GMB workshops are developed using scripts that are then combined in a complementary manner. Each script explains a specific action needed to build a CLD, such as identifying variables and linkages and reviewing earlier activities. In addition, scripts specify the expected inputs and outputs of each core activity, ensuring that the workshop procedure is consistent. To date, the Scriptapedia, created by Hovmand et al., is the most comprehensive source for creating well-structured GMB workshops in Western, high-income countries.⁴²⁷

7.2.2 The use and usefulness of GMB

GMB has been widely employed in health studies, although it is still relatively new. For example, it was utilised to better understand the factors contributing to childhood obesity in a Wisconsin urban area,⁴²⁸ determine breastfeeding obstacles and facilitators among low-income African mothers in the US⁴²⁹ and identify the factors contributing to childhood obesity in AUS.⁴²⁸ Additionally, it has been used to resolve community violence,⁴³⁰ design regulations for fishing,⁴³¹ and assess the possible environmental impact of deep-water offshore platforms.⁴³²

Several studies have used the GMB approach to address childhood obesity. For example, in 2015, GMB workshops were conducted within a Victorian community in AUS to create a CLD that describes the determinants of obesity among children in the local area.²³⁷ Participants were

able to develop a CLD that reflects local contextual factors and captures more modifiable variables than other methods had. Moreover, few studies were also conducted in the Chinese American community,⁴³³ the Milwaukee⁴²⁸ and Somerville⁴³⁴ communities in the USA. These studies demonstrate that the GMB approach can visualise the drivers of childhood obesity at the community level.

GMB as a tool to assist the development, evaluation and implementation of public health interventions is in its infancy; therefore, determining its helpfulness is difficult at this point.²³⁷ However, a recent review of 175 studies using the GMB approach found that this approach can bring many advantages.⁴³⁵ These include extracting accurate information, organising in-depth discussions, making better-informed decisions, providing more insight into the issue and its underlying structure, establishing agreement on the created model and implications, and raising a feeling of ownership and dedication to collective work.

Another review of 45 GMB studies revealed that GMB workshops could improve communication and agreement among members in workshops and accomplish various outcomes, notably in terms of facilitating members' engagement and learning during the process.⁴³⁶ Moreover, participants believe that the CLDs produced via the GMB procedure accurately represent their beliefs.⁴³⁷ In addition, the decisions made using GMB are thought to be more favourably regarded than those made in other ways.⁴³⁶ Nevertheless, comparing actions originating through GMB with those from other approaches remains ongoing.

Capacity building is an auspicious approach to addressing obesity at a population level.²¹⁷⁻²¹⁹ It is defined as the degree to which a community can identify and address its health problems. It may be done by growing community skills and knowledge, supplying necessary resources, and committing to better health.⁴³⁸ Engaging in GMB workshops can significantly improve a community's capacity to understand and respond to complex health issues, as well as the quality

of its choices and actions. In addition, developing CLDs relevant to a particular community can identify new leverage points that can be integrated into the current system for other issues.

On the other hand, some may argue that this approach can be time-consuming in settings where demands are high,⁴³⁹ and groups may take longer to make decisions. This may suggest that using the GMB approach in instances where rapid decisions must be made would be inappropriate.⁴⁴⁰ However, comparing to other intervention development approach, GMB provides an efficient and rapid way to integrate collective knowledge for decision-making. Another possible limitation of GMB is that participants' views and the produced CLD may not accurately reflect the problem or the community being assessed because participants' inputs rely on their understanding of the issue.⁴⁴⁰ This means identifying and selecting the most appropriate GMB participants is an important step to ensure the credibility and usefulness of the GMB outputs. It can also happen that one or more participants' views are repressed, and they become subservient to what seems to be the prevailing perspective of the group. An experienced GMB facilitator who can identify and handle power dynamics appropriately before (when making recruitment and grouping decisions) and during a workshop can prevent this from happening.

7.3 Rationale for this study

All empirical studies that used the GMB approach to address obesity focus on Western populations, raising concerns about the applicability of the 'GMB approach' in non-Western nations that are significantly different from Western cultures and political systems. No studies thus far have reported the feasibility of organising and running GMB in a non-Western nation, particularly among Arab nations. Furthermore, to run a successful GMB workshop, representatives from various roles or areas of the community should recognise the importance of tackling the issue and be willing and able to participate in the first place. These would be

difficult in many non-Western nations where obesity prevention is not widely recognised as a priority. Hence, there is a need to test the application of the GMB approach within a non-Western country. The findings of this GMB study are expected to inform the planning and running of future GMB workshops in Arab nations.

7.4 Research aim and objectives

This study aimed to inform the recruitment and process design for full-scale GMB workshops within the Saudi community. The following objectives were set to achieve the aim of this study:

- a) To test and identify the most feasible and efficient recruitment strategies to run a GMB in the Saudi community.
- b) To run a pilot GMB workshop in this setting and identify needed adaptations.

This study did not intend to examine recruiting strategies in-depth or to produce a CLD, but to document and reflect on the process of recruiting and running a pilot GMB workshop.

7.5 Methods

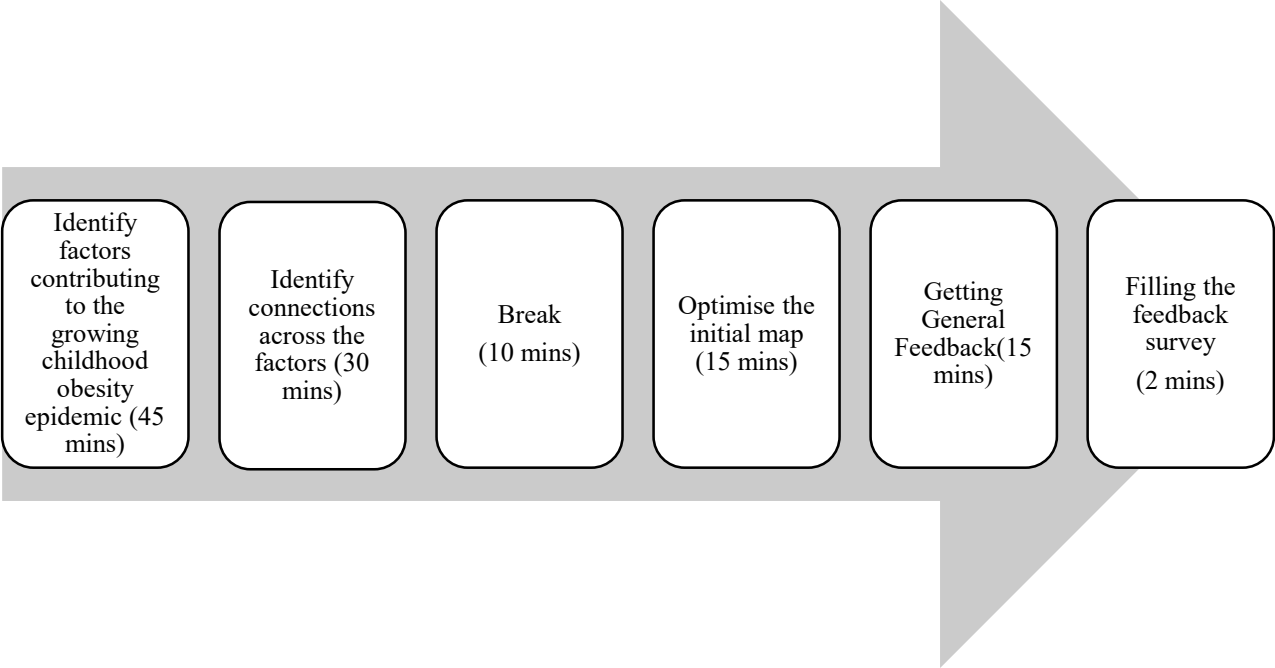
7.5.1 Study design

Participants were invited to participate in an online workshop. To design this study, a system dynamic approach was used, which aims to identify causal links, feedback loops, delays, and unplanned effects concerning a defined, complex issue. The process of the online workshop was designed with reference to Scriptapedia.⁴²⁷ However, for the purpose of the study, only the first phase of the GMB process was conducted. Therefore, some modifications were incorporated into the standard process to fit the research setting and fulfil the goal of this study (Table 7-1). Figure 7-1 outlines the structure of the virtual GMB workshop.

Table 7-1: Modifications made to the standard process of GMB and justification

The standard process	Modifications	Justification
Conducting three in-person workshops	Only one online workshop	a) Online due to SARS-CoV-2 restrictions. b) Only one workshop to suit the purpose of this study
Using a phased approach (leaders separated from the wider community)	Mixed group: involving local leaders, private sectors and broader community participants in the same workshop (including males and females)	a) This adjustment was made in response to the findings of the study in chapter 6. b) To identify the culturally acceptable composition of participants.
Modelling team, including the facilitator, modeller and notetaker	Only one person leading the whole process	a) Language barrier (lack of a 2 nd researcher who can speak Arabic) b) Financial constraints
Recording conversation and discussion (notetaking)	Video recording	a) Feasible when the workshop is done online.

Figure 7-1: The overall of the online GMB workshop.



7.5.2 Identifying and recruiting participants

Potential participants were identified (Table 7-2) purposively using pre-defined sampling criteria from LAs and other relevant organisations within Makkah city. Purposive sampling was employed to select participants because the researcher had pre-defined recruitment criteria and was looking for specific people with much knowledge about the issue studied.⁴⁰¹ The pre-defined sampling criteria included:

- a) Working in authorities that have roles in shaping the environments surrounding children (> 4 years).
- b) Being a current decision-maker or a frontline worker in a local authority or a relevant organisation, or being a former/current programme leader of childhood obesity (or obesity in general) control programme.

These criteria ensured that individuals who either have the power to make changes within the city or have expert or practical knowledge of the issues were included in the workshop. The SPS-REC at the University of Bristol approved this research project on 24 March 2021 (Reference: SPS REC/20-21/124) (Appendix 11), and all participants provided signed informed consent.

Table 7-2: Potential participants/authorities to be approached for the virtual GMB

Category/Sector	Potential Stakeholders
Governmental (central and local)	Department of parks and recreation
	Department of School Health Affairs
	General Sports Authority
	Food and Drug Authority
	Early Childhood Management Services
	Makkah Development Authority
Local Health Authority	Public Health Department in Makkah
	Social Work and Community Services
Non-profit organizations	Kayl Association for Combating Obesity
Private sectors	Fitness Time (Gym)
Individuals	Former/current leader of obesity prevention programmes
	Public health and Health promotion officers

Education and research	Department of Health Education and Health Promotion
	Department of Physical Education
	Department of Nutrition
	Department of Social Services
	Research centres
	Community Health Education Centre
	Schools

A recruitment plan was developed and discussed with supervisors. Potential obstacles (e.g., unresponsive from LAs) and tactics (e.g., using a third party) that can facilitate the recruitment of DMs were also identified. Potential authorities and organisations were compiled, and methods to reach those authorities were also identified. Recruitment materials were developed to ensure the relevancy and acceptability of those materials to the potential participants. Non-technical Arabic language was used to describe the study aims and the GMB approach. Recruitment of potential participants took place from July 2021 to December 2021. Several strategies were applied asynchronously and are presented below in the same order they were applied.

A. Formal contact with local authorities

The recruitment letter (Appendix 8) was sent to the official emails of all the authorities in the list of identified relevant organisations (Table 7-2). The letter included an overview of the study and asked authorities whether they would participate in this research project. In addition, a message was sent to those organisations through their official social media accounts.

B. Approaching decision-makers in previous studies (Chapter 6)

DMs and key informants who were interviewed in previous studies (Chapters 5 and 6) were also asked if they were interested in participating in the virtual workshop or recommending potential participants who may give insightful information.

C. Using a third party (gatekeeper)

Using a third party to act as a gatekeeper can facilitate recruitment and access to potential participants and influence the willingness to participate.⁴⁴¹ Several trusted Saudi bodies ($n=3$) were contacted to act as gatekeepers in recruiting LAs and other relevant organisations.

D. Direct contact with decision-makers

The social network of the main researcher was also used to recruit local decision-makers. Direct contact with potential participants was used, and those who agreed to participate were encouraged to recommend other participants who might be interested in the GMB approach. If they met the sampling criteria, they were contacted.

Those who expressed interest received an information sheet (Appendix 16) and consent form (appendix 17) and were asked to return them to the researcher before the workshop began. Then, participants were contacted to set up a date and time to complete the workshop that was done through the Zoom application.

7.5.3 Preparation of the GMB workshop

Preparing for the virtual GMB workshop, I was trained in GMB methods, including running GMB activities and using the STICKE software to generate a meaningful CLD. STICKE is a software developed to disseminate knowledge and develop a shared understanding of difficult circumstances within a community.⁴⁴² Standard scripts that outline what should be covered, how it should be done and expected results were used to identify and adapt group exercises that were suitable for the purpose of the virtual workshop. The workshop was conducted in Arabic, and all terminologies were translated into Arabic using lay language. Finally, a mock online workshop was conducted to identify practical issues and optimise the planned workshop activities.

Regarding workshop management, several roles are required to run a GMB workshop for the best outcomes. These roles include a) a facilitator to host, lead and guide the workshops' participants in building the CLD; b) a notetaker to record non-verbal expressions and interactions among participants, and c) a modeller to work on modelling software.⁴⁴³ However, I performed all the roles for a few reasons, such as the language. Other reasons were related to the time and financial constraints of employing and training a native Arabi modeller or notetaker. Instead, the workshop was video recorded so I could return to it to capture information such as contextual factors, body/facial expressions and verbal comments for analysis. Finally, a workshop agenda was sent to all participants a day before the workshop. Participants also received a reminder of the workshop date and time and to set up a zoom account (if needed).

7.5.4 Running the GMB workshop

The workshop began by reminding the participants of their voluntary participation and their right to withdraw at any time. The participants were also reminded that the workshop would be video recorded. The online pilot workshop was divided into three parts.

Part 1: Overview of childhood obesity in SA

This part included a presentation of the basic overview of childhood obesity in the country, the project aim, and a brief introduction to the CBSA and the GMB workshop (Appendix 18). In addition, the reasons for getting people from different sectors together were explained to the participants. Finally, this part was closed by asking participants to consider childhood obesity in Makkah city as the focus of their work.

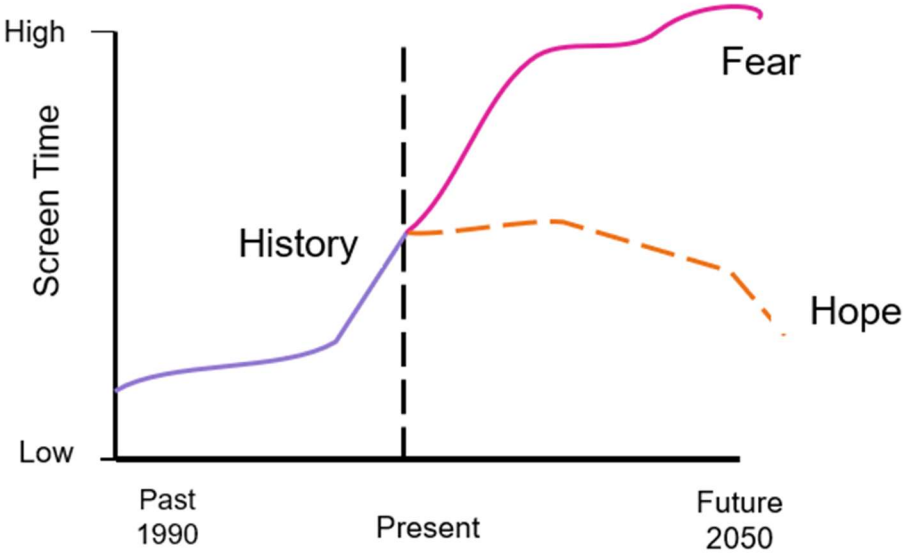
Part 2: Core GMB activities

Activity 1: Behaviour-Over Time Graphs (45 minutes)

Firstly, Behaviour-Over Time Graphs were introduced to all participants, and an example was provided (Figure 7-2). After ensuring all participants fully understood the activity, they were asked to work individually to draw as many graphs as they could (one graph for one factor only) for factors that have contributed to the growing childhood obesity prevalence in the city. Then, participants were asked to work in groups to discuss and prioritise their completed graphs (identified factors) based on the perceived importance. A breakout room feature was used to group participants randomly. Next, the researcher entered each breakout room and allowed participants to ask questions regarding the activity. Finally, the activity was closed after all members left the breakout room and returned to the main room.

The main researcher's screen was shared with participants while STICKE software was live. Then, each group was invited to describe and name their factors in turn until all identified factors had been shared. I instructed participants to avoid giving a name that specifies a direction of changes (e.g., more/less, increased/decreased). Finally, I entered each clearly defined factor into STIKE.

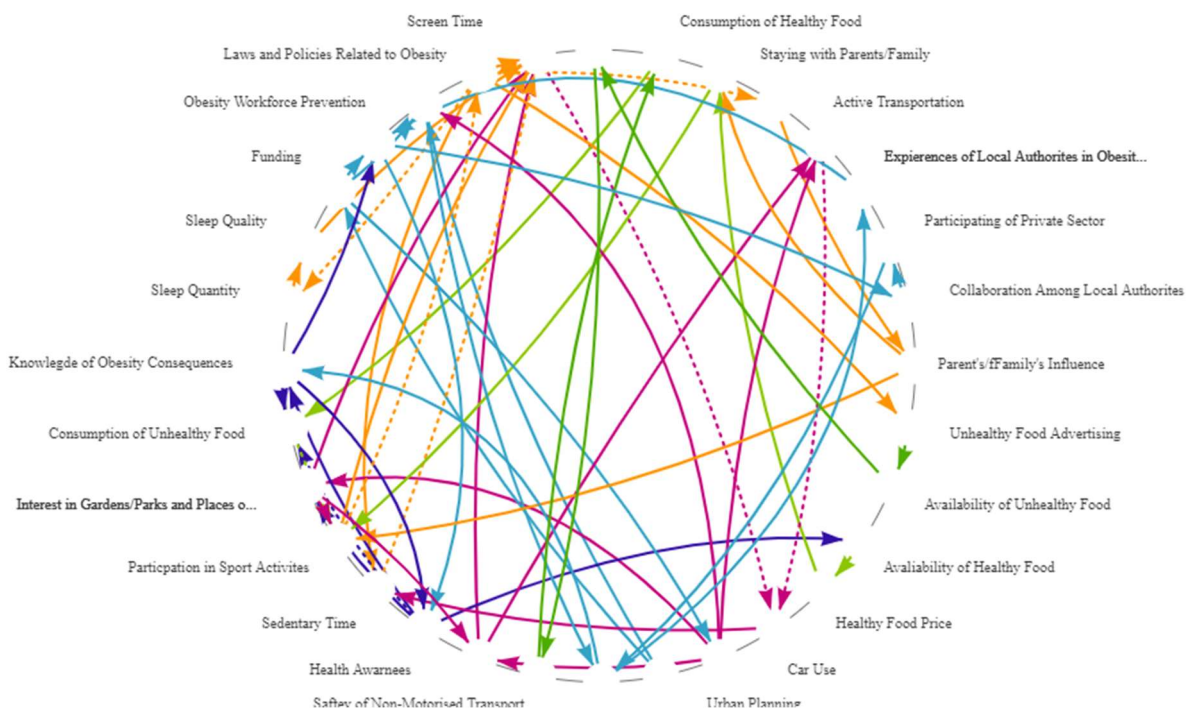
Figure 7-2: An example of Behaviour Over Time Graphs



Activity 2: Connection circle (30 minutes)

After adding identified factors to STICKE, participants were introduced to the activity of creating a connection circle (Figure 7-3) and the aim of this activity. An example of how arrows are used to indicate relationships between factors was provided. To ensure participants fully understood this activity, they were asked to pick two factors and describe their relationship. Then, participants had the opportunity to identify connections across all identified factors. Participant suggestions for connections among factors were made in an unstructured and open conversation. Next, I drew the links with participants through screen sharing (STICKE is projected). After 30 minutes, the activity was closed, and participants were given a break for 10 minutes. During the break, I reconfigured the connection circle, ensuring that the developed CLD includes minimal crossing-overs. In addition, factors were grouped into theme clusters and colour coded to improve readability.

Figure 7-3: An example of the connection circles activity



Activity 3: Optimising the initial map (15 minutes)

The updated initial map showing various contributing factors and their complex relationships was shown to participants. Participants were asked to review the map (reflecting the situation in the community), consider adding, removing, renaming any factors, or identify a new connection.

Part 3: Getting feedback from participants

This 2-part session was purposively added to this pilot workshop in order to get feedback from the workshop participants. The first part invited verbal feedback from participants about: 1) their general experience and thoughts regarding the workshop conducted, 2) perceived benefits and strengths of activities, and 3) perceivability to identify and prioritise potential interventions assisted through the GMB activities (see table 7-3 for questions that were asked during the workshop).

Table 7-3 : Questions of the feedback session (verbal feedback)

Questions
a) What do you think in general about this workshop?
b) What do you think the main benefits or strengths of these activities are?
c) Which parts of this workshop were easy to understand and take part in?
d) Which parts of this workshop were more difficult to understand or take part in? Why? How can we improve them?
e) Do you think when the map is finalised (usually this will involve at least one more workshop with representatives from diverse sectors and departments), policymakers can identify and prioritise potential interventions?
f) If policymakers can jointly determine broad intervention themes in a later workshop following the current stage, which we have tested together, do you think policymakers are willing to form Action Groups?

In the second part, participants were invited to fill out an anonymous online evaluation form (Appendix 19). The online form had eight sections and was designed to explore participants' 1) understanding of the GMB process, 2) thoughts on the recruitment strategies, 3) willingness to

participate in actual workshops in the future and 4) challenges before and during the GMB workshop.

7.5.5 Measure the success of data collection

I have defined formal success criteria to determine the extent to which the data collection process was successful. These criteria were related to recruitment participation and planned activities in the workshops. The following subheadings describe these criteria in more detail.

7.5.5.1 Recruitment and participation

According to Peter Hovmand and colleagues,⁴⁴⁴ when GMB workshops include groups smaller than five, there is a loss of the dynamics that lead to an unsuccessful GMB outcome. With this in mind for the virtual workshop, the minimum number of participants for a successful workshop outcome was 5. Another criterion was the diversity of representatives, meaning that participants should be drawn from and represent the majority of LAs and other relevant organisations.

The feasibility and success of the recruitment process were evaluated by the recruitment rate, including the number of eligible LAs invited and the number of those who participated, the number of uninterested potential participants and the reasons they declined to participate. Further evaluation metrics included the number of participants, the degree of representation of LAs relevant to childhood obesity and whether the researchers achieved the minimum required number of participants to run a successful GMB workshop. Further, I detailed the length of time taken and actual methods/strategies to recruit LAs. Reasons for withdrawing from the workshops and the timing of the withdrawals were also presented. Data pertaining to these metrics were extracted from the recruitment stage and the workshops and entered into an Excel spreadsheet for tabulation. Most of these results are shown in the results section below.

7.5.5.2 Key activities

Activities planned for the virtual workshop make up their core parts. Therefore, there should be indicators describing the successful implementation of those activities. The indicators or criteria can be linked to the intended output or the accomplishment of some learning targets. Importantly, the facilitating team's expectations for what a successful workshop looks like must not be ambiguous or conflicting. Clarifying the assessment criteria during the planning phase enables the team to understand and discuss what should occur during the workshop. Therefore, I have established a number of evaluation criteria for each activity (Table 7-4). Most of those criteria are recommended by Scriptedia.⁴²⁷

Table 7-4: Evaluation criteria for key activities

Activity	Evaluation criteria
Behaviour over-time graphs	<ul style="list-style-type: none"> • The ability of participants to identify factors contributing to childhood obesity in their community. • A self-sustaining group conversations after describing clusters. • Observing meaningful clusters. • The tendency of graphs to converge on an obvious dynamic issue. • Reflecting on graphs and thematic groups reveal a few major dynamic factors. • The beginning to see crucial stocks and probably major feedback loops • A few members show a better understanding of childhood obesity compared to other members.
Connection Circles	<ul style="list-style-type: none"> • Engagement of participants in discussing connections and factors. • The creation of multi-feedback loops in a connection circle. • The ability of participants to identify feedback loops. • The recognition of participants of the complex system surrounding childhood obesity in their community. • Enthusiasm of participants about the modelling procedure.
Optimising the initial map	<ul style="list-style-type: none"> • The ability of participants to provide new data that could be used to improve the model further.

7.5.6 Data analysis

Although this workshop was not designed to develop interventions or build a meaningful CLD, an analysis of the preliminary CLD and levels of influencing factors identified by the participants was conducted. Furthermore, recruitment quantitative data was collected in files for tabulation. The overall number of recruited participants, recruitment time, number of approached (men and women), and number of refused participants with reasons for refusing are presented. Appropriate descriptive statistics were used to analyse quantitative data. Furthermore, any methodological issues related to the recruitment and workshop process were documented so that future research can learn from this experience and choose the most appropriate way to organise GMB workshops within the Saudi community. Moreover, evaluation forms (Appendix 19) were analysed quantitatively to examine participants' understanding of the workshop process.

I kept notes during the workshop. These observations included the time spent on key activities and the extent to which those activities were performed successfully. The ability of participants to identify feedback loops was also considered. Furthermore, any difficulties facing the participants during key activities were recorded. In addition, any factors or conditions facilitating or hindering the GMB workshop process were also documented for later analysis.

7.6 Results

Several challenges related to the recruitment process were identified. However, no significant issues related to the workshop activities were identified. Minor issues were identified related to the cultural and social norms of Saudis. The following sections report the success of data collection, identified issues related to the recruitment, workshop process and the developed, preliminary CLD.

7.6.1 Measure the success of data collection

There were two main predefined criteria for recruitment and participation to achieve data collection success. The first criterion was to run the session with at least five participants. This criterion was achieved within the current virtual GMB as the virtual workshop included more than five participants. Moreover, the second criterion related to recruitment and participation was the diversity of representatives. This criterion was achieved as participants in the virtual workshop were drawn from various authorities and organisations. Furthermore, the successful implementation of key activities of the virtual GMB workshop was assessed against predefined evaluation criteria (Table 7-4). The following table (Table 7-5) shows in detail how each activity was assessed against the evaluation criteria.

Table 7-5: Evaluation of key activities

Activity	Predefined Evaluation Criteria	Assessment
Behaviour over-time graphs	<ul style="list-style-type: none"> • The ability of participants to identify factors contributing to childhood obesity in their community. • Self-sustaining group conversations after describing clusters. • Observing meaningful clusters. • The tendency of graphs to converge on an obvious dynamic issue. • Reflecting on graphs and thematic groups reveals a few major dynamic factors. • The beginning to see crucial stocks and probably major feedback loops • A few members show a better understanding of childhood obesity than other members. 	<p>These evaluation criteria were met during the activity "Behaviour over-time graphs". Participants were able to identify more than 30 factors influencing childhood obesity in their community. Participants engaged in a highly productive conversation to discuss the influencing factors and clusters. In addition, during the discussion, participants were instructed to reflect on graphs or thematic groups. This kind of discussion revealed other factors influencing childhood obesity in the local community. For example, the theme of environmental/political factors was the most discussed theme by participants, revealing some other factors related to this theme, such as "collaboration among LAs", "experience of LAs in addressing childhood obesity", and "private sector participation". Finally, it was clear that a few participants understood the issue better than others. For example, when participants provided their top priority list of factors influencing childhood obesity in their community, a participant asked others to focus more on upstream determinants rather than individual determinants.</p> <p>A few of these criteria, such as "Observing meaningful clusters" and "the beginning to see feedback loops," were assessed by me as there was no modelling team. These two criteria were met as meaningful clusters, and feedback loops were clear when the participants gave me the factors. For example, when participants provided factors such as "urban planning", " car use", and "active</p>

Activity	Predefined Evaluation Criteria	Assessment
		transportation", I realised that there is a cluster related to the infrastructure.
Connection Circles	<ul style="list-style-type: none"> • Engagement of participants in discussing connections and factors. • The creation of multi-feedback loops in a connection circle. • The ability of participants to identify feedback loops. • The recognition of participants of the complex system surrounding childhood obesity in their community. • The enthusiasm of participants about the modelling procedure. 	These criteria were also met during the virtual GMB workshop. Participants were engaged in a debate regarding the connections across factors. Participants discussed the interrelationship of factors and their influence on childhood obesity in the community. Again, environmental/political factors were the most discussed theme. In addition, multi-feedback loops were created during this activity, but a few members struggled to identify feedback loops even after providing some examples. Moreover, during the discussion, participants recognised the complex nature of childhood obesity in their community. For example, a participant said, "this is a complicated issue", in a discussion. Finally, participants were enthusiastic during the modelling process. For example, participants said, " <i>this is a fun process</i> ", " <i>I liked this activity</i> ", and " <i>interesting activity</i> ".
Optimising the initial map	<ul style="list-style-type: none"> • The ability of participants to provide new data that could be used to improve the model further. 	During this activity, participants provided valuable feedback that could improve the initial map. Most of the new data obtained from participants were related to the connections across some factors.

7.6.2 Recruitment challenges and success

A strategy of formal contact with local and some national authorities ($N=25$) using their official email or social media account was ineffective, as this did not lead to any response. Moreover, four participants of the previous study who were approached ($N=26$) agreed to participate, but only one actually attended. The direct contact strategy garnered 11 out of 15 participants approached via phone or WhatsApp. Six of the 11 participants represented various aspects of the community, including the public health department, health promotion centre, school principals and local health promoters. Table 7-6 below shows each recruitment strategy and the number of recruited participants.

Table 7-6: Details of recruitment strategy

Recruitment strategy	No. of approached	Gender	No. of agreed, No. of disagreed and Reasons for refusal	No. of participants attended the session
Formal contact with LAs	25 authorities	Unknown	(N=0) No response at all	0
Approaching participants of previous studies	26 participants	<ul style="list-style-type: none"> • 12 females • 14 males 	<ul style="list-style-type: none"> • 4 participants agreed to attend the session. • 12 participants agreed in principle but asked to be contacted later. They were contacted when the workshop was planned to be conducted. I got no response from 8 participants, and 4 participants refused due to busy schedules. • 10 participants declined and asked for formal approval from the central authority. 	<p>Among the 4 participants who agreed to attend the session:</p> <ul style="list-style-type: none"> • Only 1 participant attended the online session. • 2 could not attend due to time conflicts, • 1 participant did not respond.
Using a third party (gatekeeper)	3 entities	Unknown	Only 1 entity agreed. However, I discontinued using this strategy due to time constraints. Reasons are provided in the result section.	
Direct contact with decision-makers	20 decision-makers and frontline workers	<ul style="list-style-type: none"> • 17 males • 3 females 	<ul style="list-style-type: none"> • 11 participants agreed to attend the session. • 7 participants did not respond. • 2 participants asked for formal approval from the central authority. 	<p>Among the 11 participants who agreed to attend the session:</p> <ul style="list-style-type: none"> • Only 6 participants actually attended the session. • For the other 5 participants, see the note (next row) below.
<p>Note: Five individuals joined the session and left immediately. I contacted them immediately after the workshop, and only three participants replied. Two participants faced an internet connection issue, and another had an urgent one. Two participants did not respond. The discussion section below reflects on this issue.</p>				

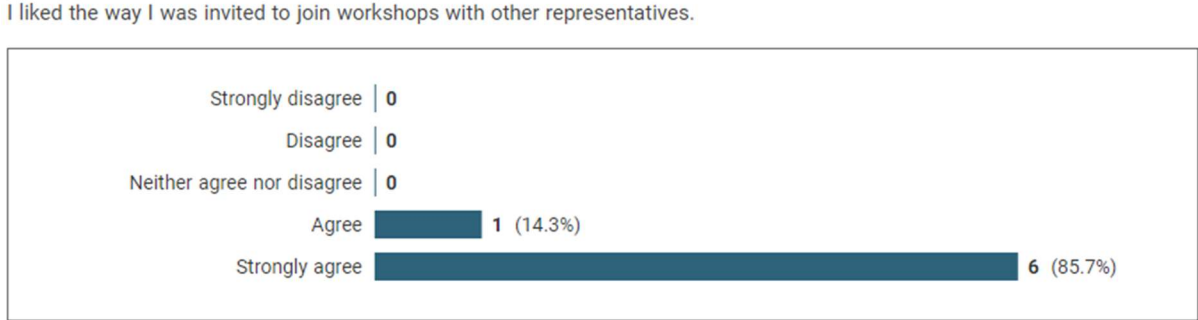
Hiring a third party (gatekeeper) to help recruit representatives from LAs and other relevant organisations was time-consuming. This strategy involved contacting specific entities with power within the community to hold this workshop in cooperation with the researcher. Three entities were approached, and two entities did not respond. The entity that initially agreed to hold this workshop and recruit other authorities asked for more information, such as the study protocol and potential authorities. All required information was sent to the entity. However, the entity took a very long time to approve and sometimes unresponsiveness to e-mails from the researcher.

Participants who joined the session and left immediately were contacted immediately after the virtual workshop. I asked them why they left the session and if they withdrew from the study. Unfortunately, I got the replay only from three participants after the workshop. Two participants were facing an internet connection issue, and the third participant had an urgent family issue. Regarding which organisations they are working for, three participants are working in the local health authority and the municipal council. The others are working in NPOs and school health affairs. The lesson learned from this experience is provided in the discussion section (7.7.2).

The time taken to recruit participants was around 4-5 months. All participants were males, although female DMs were approached and agreed to participate but did not attend the virtual session and did not provide a reason for not attending. The most common reason for refusal to participate in the workshop was the lack of approval from the central authority, which took approximately 4-5 months. Also, some participants refused to participate because they did not see the relevance of their roles in childhood obesity prevention. Finally, others refused because of their busy schedule.

Analysis of the evaluation forms (Appendix 19) indicates that all seven participants were satisfied with the recruitment strategy, and six strongly favoured the way they were invited to the workshop (Figure 7-4).

Figure 7-4: Participants' satisfaction with the recruitment strategy



7.6.3 Workshop process

Results from the evaluation form (Appendix 19) indicated that 5 participants found the key activities easy to understand and could teach them to others. Moreover, 3 participants found that the most challenging exercise in understanding and participating is 'connections across factors' (Figure 7-5). Additionally, 4 participants found the 'behaviour over time graphs' the easiest activity to understand and participate in (Figure 7-6).

Figure 7-5: The most challenging part of the virtual workshop

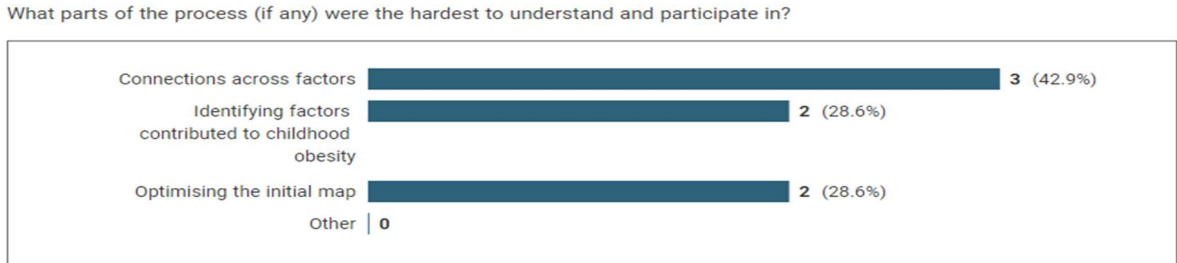
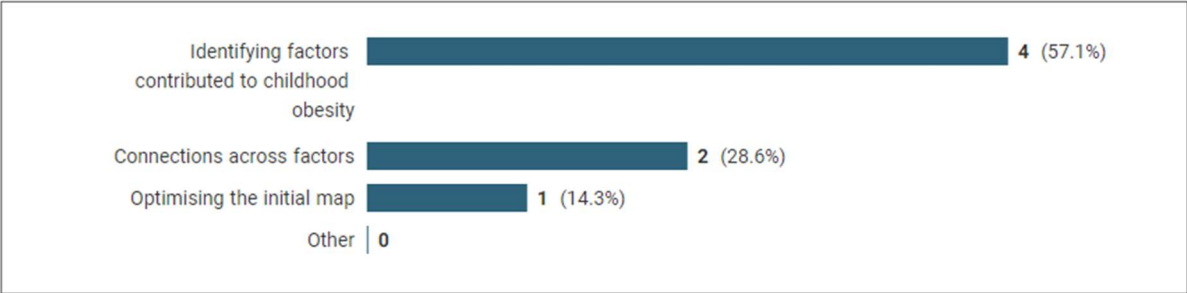


Figure 7-6: The easiest part of the virtual workshop

What parts of the process (if any) were the easiest to understand and participate in?



Regarding the perceived usefulness and feasibility of the GMB approach within the Saudi community, all participants strongly agreed on the usefulness and feasibility in the real world within the Saudi community (Figure 7-7). Moreover, the open-ended responses revealed that a) there is a need to disseminate this way of working among public health professionals and specialists in the country, and b) the process is fun and interesting.

Figure 7-7: Usefulness and feasibility of the GMB approach within the Saudi community

I think this approach would be useful and feasible in real-world within the Saudi community.



7.6.4 Feedback session

During the 15-minute feedback session, all participants were given the opportunity to respond to the questions listed above in Table 7-3 and remark on any other subject relating to the workshop. Participants revealed considerable information regarding the workshop itself and other actions related to the GMB approach. A first insight is that some participants admitted

that this method is missing from work on public health issues in the country and expressed the need to generalise this approach to the bodies concerned with the fight against obesity. Furthermore, participants revealed that none have ever participated in a workshop like this or been exposed to such a way to solve complex problems. However, some participants expressed the need to invest more time in explaining each activity before holding the workshop in the real world.

A second insight is that all participants expressed that the strength of the workshop relies on the discussion and sharing of ideas among the participants. In addition, most participants positively evaluated their involvement in the virtual session. Some participants mentioned that they would transfer this method to their authorities/organisations, but they need to be trained in such methods. The experience offered them a new way and perspective of seeing the public health issues they work on. One of the participants working for a governmental authority questioned me, before participating in the workshop, why he or his authority was invited to participate, although there are no roles for his authority in childhood obesity prevention. After this workshop, this participant informed me that he had realised the importance of this approach and his authority's role in childhood obesity prevention. Finally, some participants found the workshop effective in addressing complex issues such as childhood obesity and expressed their wish to do more experiments.

A further insight is related to the perceived ability of policymakers to identify and prioritise potential interventions if they participate in a similar workshop and a full GMB process is followed. Some participants were reluctant to answer but believe that policymakers and relevant bodies should be able to identify potential interventions and form working groups if the model is built by them or their authorities.

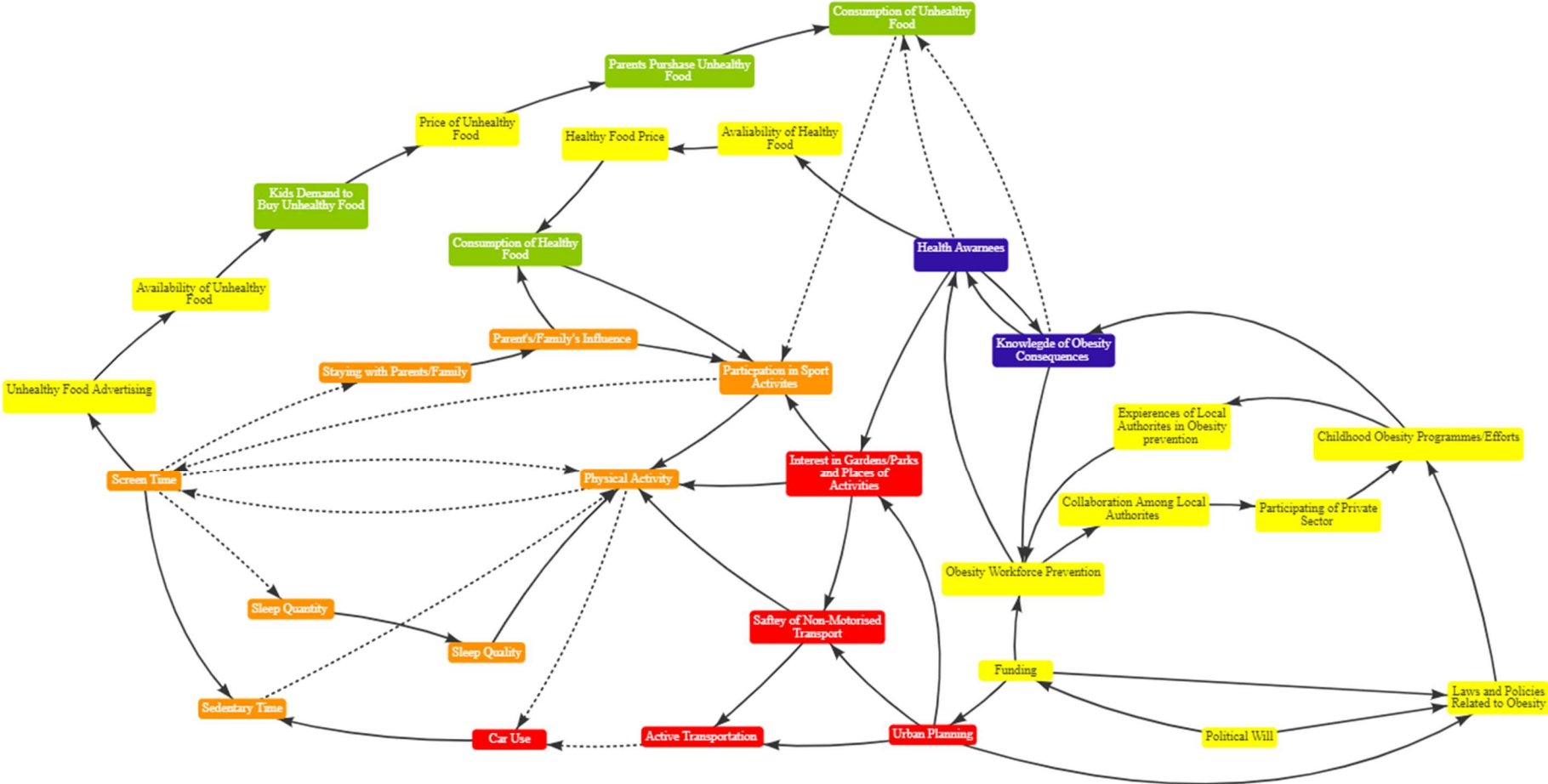
7.6.5 Analysis of the created model and the related issues

Participants were able to identify multiple levels of factors influencing childhood obesity in their local area (Figure 7-8). The key themes included eating habits, PA and sedentary behaviour, infrastructure, environmental/political, and knowledge factors.

There were some issues identified during the process of building the preliminary CLD. The first issue was that some participants could not identify upstream factors until given examples. For example, one of the participants asked others not to mention individual factors because they are known to everyone, and the focus should be on other factors, such as political, societal and environmental factors. Moreover, identifying feedback loops was a significant issue for some participants, although they were given an example of feedback loops. Three participants were able to identify feedback loops without giving additional examples.

A further issue was related to engaging in the discussion. Engagement levels were varied among participants, with some more willing to share their views while others were more reluctant. This issue was expected during the preparation for the workshop because participating in virtual sessions may require more energy from participants than in physical workshops. To ensure that all participants had an opportunity to speak up, each participant was encouraged and asked to offer their ideas by the researcher. Finally, participants spent much time discussing how the political will was involved in reducing or increasing childhood obesity in their community.

Figure 7-8: The CLD created by GMB's participants



Keys: Green= Eating Habits factors; Orange= PA and Sedentary behaviour factors; Red= Infrastructure factors; Yellow= Environmental/Political factors, Blue= Knowledge factors. Solid line= Positive association; Dashed line= Negative association.

7.7 Discussion

7.7.1 Key findings summary

This study aimed to inform the future organising and running of GMB workshops within the Saudi community. Although several strategies were applied, recruiting DMs from LAs or organisations was quite challenging. The COVID-19 pandemic might have worsened the situation. Nevertheless, this study revealed some issues related to the workshop process or cultural context among participants. All participants did not have a prior experience with the GMB approach but reported the usefulness and acceptability of this approach within the Saudi community.

From my experience and observation, I noticed that some participants (frontline workers) were trying not to contradict or debate the input of DMs in the workshop. As a result, it is recommended to hold future GMB workshops using the phased approach in which DMs and other non-senior workers are not in the same workshop as advised by the standard GMB workshop.

A further observed issue is related to the gender of the attendees. There were no female attendees in the workshop. In fact, there are not many women taking the roles that meet my recruitment requirements. In addition, the lack of women in the GMB workshop could be due to the cultural and social norms in SA regarding gender segregation which have been recently removed. This could be seen as a minor cultural issue that needs to be addressed when running GMB workshops within the Saudi community. This minor cultural issue could be addressed by conducting segregated workshops. Issues regarding gender segregation were highlighted in Chapter 6 by a few female DMs who preferred not to attend a workshop with males in the same session or hall.

Another observed issue is that most LAs do not fully understand community-based participatory research. This kind of research is still a novel concept and not well-established among LAs and other relevant organisations. Considering the Saudi Vision 2030 to improve public health,²⁶² there is an urgent need to raise awareness of authorities on the benefit of participating in community-based participatory research, which ensures a thriving community and improves population health supported by scientific evidence.

An important observed issue is that language adaptation is essential to the practice of GMB workshops because some English vocabulary does not have an equivalent in Arabic, so the researcher must explain it to the participants. As a result, future researchers interested in conducting GMB workshops in Arabic are advised to prepare linguistically before the start of the workshop to improve participants' comprehension of activities and, in turn, get an effectual workshop output.

Since the primary aim of this GMB study was not to produce a meaningful CLD but to test the process of organising and running a GMB workshop, the created CLD (Figure 7-8) is not perfect and meaningful. In reality, researchers balance what the participants suggested and the available scientific knowledge (held by the researchers). Over the phased GMB process, the CLD get reviewed and refined. If I were to do one or two more pilot workshops, some of the current variable names/connections would have been modified.

7.7.2 Findings in relation to the international literature

This study experienced challenges in recruiting LAs and other relevant organisations. Findings align with other studies that found that recruiting governmental agencies is often more time-consuming and costly than planned.⁴⁴⁵ Three recruitment strategies were applied to recruit DMs from LAs and other relevant organisations. The only strategy that worked was direct contact with decision-makers, although few agreed to participate. Therefore,

active strategies, including direct or face-to-face contact with authorities' leaders, are recommended for researchers to conduct GMB workshops within the Saudi community. This is congruent with the literature demonstrating that 'less personal' recruiting strategies are often ineffective.⁴⁴⁵

Moreover, the current study could not continue with the second recruitment strategy (using a gatekeeper) due to delays in securing approval from the selected gatekeeper. Using a third party to help recruit authorities and organisations may work in Saudi society. The use of gatekeepers may help support the credibility of the research and thus convince LAs and increase the chances of their participation in the research. Also, some authorities may participate when trusted bodies approach them.⁴⁴⁶ However, future researchers are advised to develop a relationship with a partner organisation (gatekeeper) to save their research time and allow sufficient time for gatekeepers' approvals.

The issue surrounding recruitment and formal contact with authorities may also be attributed to my limited experience in liaising with decision-makers. I am an early career researcher who did not hold any leadership role in this country that is relevant to the work of the targeted organisations/authorities. In addition, it is important to point out that this strategy might have worked better if the workshop had been initiated and organised by a local or a national authority or a known community leader.

A major issue related to the virtual GMB workshop was the leaving of a few participants at the early beginning of the workshop. After the workshop, I immediately contacted those participants enquiring about their reasons for leaving the session. Unfortunately, I could not contact them during the workshop because the workshop had started, and I was the single person running the workshop. If there had been a co-facilitator, the situation might have been different, as the co-facilitator could have contacted those individuals during the workshop

and offered support if needed. As previously mentioned, reasons for leaving the workshop included issues with internet connection and urgent issues. The internet connection issue was expected, as Internet coverage is slow and weak in some areas. Moreover, after the workshop, those participants were asked if they would provide feedback on the CLD. Two participants did not respond, one participant agreed to provide feedback, and two refused to provide feedback as they did not know how the CLD was built. These participants were offered one-to-one sessions to explain to them how the CLD was built; one participant could not specify a date and time due to a busy schedule, and the other did not respond anymore. Moreover, participants were asked about their satisfaction with the recruitment strategy used to invite them to the workshop. The question was read out to participants precisely as written in the survey, and choices were given to them. One participant selected 'agreed', and the other two selected 'strongly agreed'. Other survey questions could not be asked to those participants as they did not attend the whole session. Finally, the leaving of those participants from the workshop does not mean that the voice/perspective of their organisations/authorities was not present during the development of the CLD because other participants were working in the same sectors and expected to have the same knowledge. For example, one of the participants who left the session is working in the city council; on the other hand, another participant working in the city council stayed for the whole session.

The key lessons learned from this major issue were that the facilitator team has to expect this issue to happen, particularly when the workshop is running virtually. Therefore, the team has to develop a plan for dealing with this issue, such as keeping contact details for all participants and the names of the organisations they belong to. In addition, the contingency plan should also include how to obtain general feedback on the developed CLD from participants who left the session. Moreover, the team must ensure that there is no lack of

perspective of a major organisation or authority in the developed model when this issue happens. This could be ensured by inviting two participants from each authority or sector.

Regarding the workshop process, participants did not reveal any major issues that could hinder the application of the GMB workshop within their local community. Notably, GMB activities have contributed to developing participants' understanding of system dynamics in general and the complexity of obesity in particular. Moreover, participants were able to identify some factors that contribute to obesity among children in their local community. Similarly, several studies have demonstrated that GMB exercises enable participants to know dynamic behaviour strongly.^{237,433} However, participants of the virtual workshop revealed a challenge faced them during "connections across factors" and "identifying feedback loops". This difficulty was expected as it is a part of the aim of the exercise, which is to visualise complexity,^{237,447} and a short time (30 minutes) was allocated to perform the activity. However, this challenge is expected to be minimised when holding large-scale GMB workshops.

At the beginning of the workshop, some of the participants had a feeling that they were unable to build a model. However, these fears were dissipated, and they could learn from the activity and build a model. Similarly, an Australian study also found that some participants lacked confidence and the ability to build the model, which disappeared after the start of the activities.⁴⁴⁸ It was found that prior knowledge of systems science/modelling is not required from GMB workshop participants in order to get systems insights.⁴⁴⁹ This is consistent with the results of this study as not all participants had previous experience with or knowledge of the GMB approach.

Participants' feedback on the process was encouraging. Participants reported that the process was easy to understand and expressed their willingness to participate in a full-scale GMB

workshop. Furthermore, all participants of the virtual GMB workshop agreed on the usefulness and feasibility of the GMB approach within the Saudi community. However, participants questioned whether the policymakers would be able to form action groups, as the approach would need funding and commitment from all partners. Therefore, further running and evaluating full-scale GMB workshops within the Saudi community involving distinct stakeholders is required to determine the feasibility of the GMB approach to address complex public health issues.

As reported earlier, this study suggests a language adaptation to enhance the value of this approach before organising and running the GMB approach within the Saudi community or the Arab community in general. This finding is consistent with two other studies using the GMB approach in Malawi⁴³⁹ and Australian Aboriginal.³⁶¹ A future study is required to find and assess the language modifications needed for the GMB approach in Arab nations. Moreover, the systems-based approach focuses on building the community's capacity to apply and lead the GMB approach.⁴⁴⁴ Therefore, it is necessary to build the capacity of Saudis so that they can lead future GMB workshops.

7.7.3 Strength and limitations

This study's main strength is that, to the best of my knowledge, it is the first study to detail the issues related to recruitment and the GMB workshop process in the region. Another strength is that this study can serve as a blueprint for future researchers interested in organising and running a GMB workshop within the Saudi community or other Arabic countries. However, certain limitations should be considered. This was a pilot study, and the findings need to be further confirmed by additional studies examining the feasibility of the GMB approach within the same setting. This study was done online (remotely) and running only by one person, so perhaps some problems may disappear, or other problems appear

when the workshop is held in attendance. In addition, findings must be interpreted within the context of the study. Another limitation is the relatively low number of participants in the virtual workshop. However, this limitation was overcome by the diverse spectrum of participants from different authorities and organisations. Finally, this study did not aim to build a meaningful model, so not all phases of the GMB workshop were applied. Therefore, there may be other unidentified issues related to the other stages of the workshop.

Despite these limitations, this study has several implications. First, findings revealed the potential acceptability and cultural relevance of the GMB approach to the Saudi community. This means that Saudis are encouraged to apply this approach to embrace shared understanding and address complex public health concerns. Second, Saudi leaders must take on the responsibility of adjusting the standard GMB process to their preferences in order to ensure that future initiatives are appropriately aligned with the Saudi people.

7.8 Conclusion

This study demonstrates the potential use of the GMB approach to address childhood obesity or other public health issues within the Saudi community. It was found that recruiting DMs from LAs was quite challenging. The strategy of direct contact with DMs is seen as the most acceptable in this community. There is also a possibility of implementing this workshop in cooperation with a third party, but researchers should allow enough time because approvals may be delayed. Moreover, this study revealed no significant issues related to the workshop process among participants. Some simple issues were identified as expected during the connections circle activity. However, these challenges are expected to be minimised when the workshop is held in person and on a larger scale. Participants' feedback on the usefulness of the GMB approach to the Saudi community was positive.

The findings of this GMB study are valuable to policymakers and researchers as it serves as a foundation for organising and running future GMB workshops within the Saudi community. Future research is required to hold GMB workshops, including all stages of the GMB on a full scale within this community, alongside with evaluation process of GMB workshops. Furthermore, conducting more GMB workshops within this country would help identify the most comprehensive way to run GMB workshops.

7.9 Chapter summary and contribution to the thesis

This chapter detailed a virtual GMB workshop conducted with Saudi DMs and frontline workers. Recruitment challenges and the success of LAs were presented. The most effective strategy was direct contact with decision-makers, and the most time-consuming strategy was using a gatekeeper. No major issues were identified regarding workshop activities. However, minor issues related to the cultural context need to be addressed before conducting the GMB approach within the Saudi community. Finally, language adaptation is recommended before running the GMB approach.

This study provided a valuable contribution to achieving the main aim of this thesis. Specifically, it produced insights into how to organise and run the GMB workshop in a culturally appropriate way within the Saudi community. The findings of this study, when integrated with other studies' findings, are expected to provide insights into the feasibility of applying CBSA to developing childhood obesity prevention within the Saudi community. Therefore, the next chapter integrates findings from all previous Chapters (3,4,5,6,7) to determine the feasibility of applying CBSA to developing childhood obesity within the Saudi community.

Chapter 8: Discussion, Recommendations and Conclusion

8.1 Chapter overview

This thesis reported a study that aimed to assess the feasibility of applying the CBSA to developing childhood obesity prevention interventions in Makkah, Saudi Arabia. This chapter begins by revisiting the main aim and objectives of the thesis and how these objectives were achieved. Then, the findings of each study are summarised and discussed, considering existing literature. The limitations and strengths of this thesis are also examined. I also set out the implications of this thesis for central and local government, NPOs, the private sector and research. Finally, the contribution of this study to the literature is presented.

8.2 The main aim and objectives of the thesis

This thesis aimed to assess the feasibility of applying a CBSA to developing childhood obesity prevention interventions in Makkah, Saudi Arabia. As a result, the following were accomplished to fulfil the main aim of this thesis:

- a) Conducting a systematic review to identify modifiable risk factors of childhood obesity in SA and mapping findings onto the SEM (Chapter 3).
- b) Carrying out a scoping review to identify what has been achieved to date in terms of applying the systems approach to obesity prevention, with a focus on evidence on effectiveness, common features of programmes that have made a comprehensive application of a systems approach, reported barriers and facilitators to apply this approach (Chapter 4).

- c) Carrying out a qualitative study (8 interviews) using the CRM to determine the stage of readiness of the Makkah community for addressing childhood obesity (Chapter 5).
- d) Carrying out a qualitative study (18 interviews) using semi-structured interviews with DMs to explore further barriers and facilitators of applying the CBSA to developing childhood obesity prevention interventions in Makkah (Chapter 6).
- e) Conducting a virtual pilot GMB workshop with local decision-makers and frontline workers to test and understand recruitment and workshop process issues to guide and optimise future work (Chapter 7).

8.3 Key findings summary

8.3.1 Objective one

This objective was to characterise and synthesise the existing literature on modifiable risk factors of overweight and obesity among children aged 2–18 years in SA. I conducted a systematic review including 25 cross-sectional and case-control studies. The review found that previous research in SA has predominantly focused on individual-level risk factors, with little/no research on the environmental, community and policy factors. In addition, at the individual/behavioural level, the review found inconsistent evidence on PA, ST and eating behaviours and conflicting evidence for SES.

8.3.2 Objective two

I conducted a scoping review to identify and synthesise studies/programmes that have comprehensively applied a systems approach to obesity prevention. This review found few programmes that met the inclusion criteria. Those criteria were strict (explained in detail in Chapter 4), which explains the small number of included programs. Programmes/studies

were considered a comprehensive application of the systems approach if they met all those criteria associated with the development, implementation and evaluation stages of an intervention's life cycle. Evidence on the impact of taking a comprehensive approach to obesity prevention is still limited, although one study found a positive impact on behavioural outcomes and QoL. In addition, the review identified common features shared by studies/programmes that made a comprehensive application of the systems approach to obesity prevention. These features include a) mapping the systems of obesity drivers and embedding actions within the systems; b) measuring ongoing changes, not just the endpoint outcomes; c) measuring intervention processes; d) local decision-makers and influential actors (instead of researchers) lead and own intervention development and implementation; and finally, e) supporting capacity building as an essential goal alongside achieving clinical effectiveness.

This review also identified some barriers and facilitators related to applying the systems approach to obesity prevention. The identified barriers include poor understanding of 'team member' responsibilities and poor health literacy among GMB participants. Furthermore, facilitators include the process of implementing the systems approach itself, focusing on community assets rather than lacks, and finally recognising the complex nature of obesity and the need for collective actions. The review also showed that poor reporting might partly explain why only a small number of studies met the inclusion criteria, which led to the idea of developing practical guidance for the reporting, reviewing and evidence synthesis of authentic systemic work in obesity prevention and other public health challenges.

8.3.3 Objective three

This objective was to assess the readiness of the Makkah community to address obesity among children under 18 years. Semi-structured interviews were conducted with key

informants drawn from different authorities in Makkah city to assess the context in which the Makkah community are acting to prevent obesity among children. Interviews followed the topic guide of the CRM.

Based on the scoring system of the CRM, I found the Makkah community appeared to have reached 'the preparation stage', where childhood obesity was recognised as an issue, with organised relevant stakeholders and preventative activities. However, the qualitative findings revealed a different picture. For example, key informants stated that most efforts are run in isolation by two stakeholders (ministries), including MOH and MOE, which means that not all relevant stakeholders are engaged in childhood obesity prevention.

Interestingly, although the highest score was found on the dimension of “Existing Efforts”, the lowest scores were found for two dimensions: “Knowledge of Efforts and Community Climate”. As a result, this finding raises issues about whether enough resources are being committed to promoting community awareness and involvement in current efforts. Importantly, findings suggested a mismatch between community residents and leaders, as community members were not satisfied with the efforts provided and desire high-level efforts to address childhood obesity. This is a valuable finding, as it indicates that leaders have insufficient knowledge of the desires and needs of their community, leading to the design of ineffective interventions and perhaps the reluctance of community members to engage in such efforts.

Findings of the CRM dimensions revealed several issues related to addressing childhood obesity in the city. These issues were related to the limited communication and cooperation among LAs and the absence of partnerships and collaborative works to address the issue. Furthermore, the leadership dimension revealed a minor concern and support and conflict on the priority of addressing childhood obesity. In addition, the CRM dimensions revealed

several issues related to the capabilities and capacity of LAs, such as limited knowledge on preventing or avoiding the issue, limited training to the local community, lack of community engagement, limited public health experts, and limited financial resources and sustainability of financing.

8.3.4 Objective four

This objective was to explore the DMs' perceptions of potential barriers and enablers to applying the CBSA for developing childhood obesity prevention interventions within the Saudi community. I conducted 18 semi-structured interviews with DMs representing different authorities and organisations in Makkah. The study revealed limited capacities among LAs. For example, monitoring and evaluation were identified as the weakest capacities of LAs, along with limited financial resources and a lack of data and public health experts. A further major finding is the limited capabilities among the local workforce, including a lack of experience and knowledge in systems work and participatory approach to prevent childhood obesity or other NCDs and limited knowledge about childhood obesity prevention. Moreover, findings revealed a priority conflict among authorities on tackling childhood obesity, aligning with overlapping roles and responsibilities.

This study also found that although most DMs recognised the importance of the private sector in addressing the issue, there is a complete absence of the role of the private sector due to the difficulties in starting partnerships. DMs revealed that these difficulties are related to the bureaucracy and the right of local authorities to operate in total freedom and without interference. In addition, findings revealed a lack of collaborative work, long-term communication and coordination among authorities regarding childhood obesity

prevention. These findings were also identified in Chapter 5 as limitations of existing efforts addressing childhood obesity.

This study also found a political will to reduce obesity at a national level by implementing some policies such as taxation, creating and dismantling new departments within authorities to address obesity, and signing non-compulsory pledges with food industries. Moreover, local leaders support integrative responsibility for addressing childhood obesity through systems work and a participatory approach. However, a lack of experience and knowledge of systems work was identified as a major obstacle to applying systems science tools such as GMB workshops within this community. In addition, a few cultural and administrative issues, such as centralisation, were identified as barriers to conducting such workshops within the Saudi community.

8.3.5 Objective five

This objective was met by organising and conducting a virtual GMB workshop with participants drawn from local authorities and organisations. Although several strategies were applied, recruitment of local authorities in such workshops was challenging. It took 4-5 months to recruit representatives from local authorities. Direct contact with decision-makers of authorities via phone or WhatsApp appeared as the most efficient strategy to engage participants in this study. Approximately all participants strongly agreed with the way they were invited to the workshop. Moreover, this study found that formal contact with authorities using their official email or social media accounts was ineffective. In addition, using a gatekeeper to help in the participant recruitment process was too lengthy, required more time to coordinate, and was associated with a high bureaucracy.

Regarding the key activities of GMB, there was a lack of experience in GMB workshops or other similar works. In addition, the major issue related to the virtual GMB workshop

was related to those participants who joined and immediately left the workshop. This issue was discussed, and suggestions for future works were given in detail in Chapter 7. Moreover, participants strongly agreed on the usefulness and feasibility of the GMB approach within their local community. Regarding the created CLD, participants were able to produce a CLD representing drivers of obesity among local children and identify feedback loops regardless of the meaningfulness of the produced model. However, around half of the participants identified the "connection circle" as the most challenging part of the GMB process.

Feedback sessions during the workshop revealed participants' recognition of policymakers' ability to identify and prioritise potential interventions, the need for training and more experiment in the GMB workshop, and the acquisition of new ways and perspectives to solve public health issues. Moreover, language adaptation and composition of participants (DMs VS frontline workers) were also critical to producing a meaningful workshop.

To sum up, the findings of this PhD study indicate that applying a CBSA to developing childhood obesity prevention interventions in Makkah city appears challenging and not feasible, at least at the current stage. Clearly, much work needs to be done and areas to be improved. Despite a few encouraging signs, such as the support of community members for scaling up, the national political will, and the support of DMs to take a systems approach, there are some fundamental issues that hit at the operational foundation of a systems approach. These issues are discussed below in section 8.4, including the current limited evidence-based on childhood obesity, ineffective local leadership, lack of collaborative work and partnership, limited capacity of LAs and capabilities of systems thinking. Finally, it is worth noting that these concerns are interrelated, strongly connected and have varying degrees of impact on one another.

8.4 Comparison of results with international literature

To the best of my knowledge, this is the first study to assess the feasibility of applying the CBSA to developing childhood obesity prevention interventions in a Middle East country and might be one of the first studies to assess this in a non-Western setting. In addition, there is not much directly relevant literature and empirical studies on Saudi as a country and as a population on the themes of obesity prevention and leadership, collaboration, capacity and capabilities. Consequently, comparing the findings of this thesis with previous studies is challenging. However, the following sections compare findings with those of others who have studied the processes and principles of systems work internationally and discuss *why* and *how* those issues act as barriers to taking a CBSA within the Saudi community.

8.4.1 Current evidence base

Taking a CBSA to childhood obesity requires investigating *what* and *how* risk factors of childhood obesity change and interact with each other over time as a dynamic system (s). However, research of this kind is lacking for Saudi children, as demonstrated in this thesis. In particular, there is a relative lack of research on *what* and *how* community, policy and environmental factors contribute to obesity among Saudi children. Moreover, this thesis demonstrated that the existing evidence base is built only on cross-sectional studies and assumes a simple linear cause-and-effect model with a predominantly focus on individual risk factors. Previous reviews about Saudi Arabia support this finding. For example, a review of 23 cross-sectional and case-control Saudi studies to examine the prevalence, risk factors and management of childhood obesity found a scarcity of research on obesity among Saudi residents under 20 years,⁴⁵⁰ and pointed out the lack of intervention studies and the lack of research on 'upstream' determinants of childhood obesity. In addition, a

recent review of the prevalence and lifestyle factors of childhood overweight and obesity among Saudis reported a lack of in-depth research exploring risk factors associated with obesity among Saudi children.⁴⁵¹

Generally, MECs lack the rigour required to build a solid evidence base for scaling up health promotion initiatives, especially if the data are to be used to inform policy formulation and implementation.^{452,453} Reasons for lacking this kind of research in this area are varied, including but not limited to lack of support, funding, investment in health research and low social value of research.⁴⁵⁴⁻⁴⁵⁶

Within the childhood obesity prevention research field, Saudi research is falling behind international research efforts that have moved forward to develop a deeper understanding of the complicated drivers of numerous health issues. This relative lack of high-quality research, which is also accompanied by a lack of data (described in detail in section 8.4.4 below) from governmental bodies regarding childhood obesity within the country, is a core challenge that may make it difficult to determine the drivers of obesity among Saudi children. Moreover, this gap in research may impede the effective use of the CBSA and the adoption of evidence-based policy to develop obesity prevention interventions among Saudi children. For example, evidence-based research, including risk factors research and evaluation research, has been a foundation for taking the CBSA in the Netherlands.⁴ Moreover, the literature documented the importance of evidence in persuading policymakers to favour policy change. For example, evidence of various forms in AUS, including evidence on the prevalence, economic and health impact of obesity, were crucial in gaining support from policymakers and other external stakeholders.⁴⁵⁷

Recently, several efforts have been well described to apply systems thinking tools such as Social Network Analysis, Agent-Based Modelling and GMB to better understand and

address childhood obesity in AUS.^{237,458,459} Therefore, Saudi researchers are needed to reframe childhood obesity prevention research within the context of systems science. This reframing involves incorporating systems thinking into research activities,²³¹ shifting from linear thinking to non - linear systems thinking. This kind of shifting is now prioritised as a core prevention research element.³⁶⁰ In addition, Saudis are recommended to assess the impact of current obesity-related policies to justify their ongoing implementation and inform crucial adjustments to increase impact.⁴⁶⁰ Saudi academic institutions and researchers are encouraged to include policymakers in setting priorities for health research to produce policy-relevant research in response to policy-makers' demands and goals.^{452,461}

When these changes to research on childhood obesity in SA are considered, it might partially improve the feasibility of applying the CBSA since high-quality and policy-relevant research provide policymakers with good evidence to construct effective and durable systems-based interventions.

8.4.2 Leadership

The literature on using the CBSA to address complex public health issues, including obesity, emphasises the importance of local leadership in obesity prevention. In addition, Chapter 4 emphasises the critical role that local leaders play in systems change. Passionate and enterprising leaders are required to stimulate systems change.⁴⁶² However, from the perspective of key informants and DMs, this thesis demonstrated that the role of local leaders might be ineffective within the Makkah community. In particular, there is little concern and support aligned with conflicting priorities among local leaders on childhood obesity prevention. This finding is in line with that of another study conducted in a middle eastern country, Iran. The authors reported that the issue of childhood obesity is a concern but not a top priority for local leaders.³⁷³ This raises an issue regarding the use of a CBSA

for obesity prevention within the Saudi community because applying a CBSA largely depends on local leaders who can work as steering committees to ensure effective implementation for achieving systems change.^{239,413}

An essential factor in the steering committee that enable diffusing systems interventions is leaders' knowledge regarding childhood obesity prevention.²³⁹ Unfortunately, the level of knowledge among local leaders regarding the prevention of obesity is limited, meaning that the essential factor is not achieved within the Saudi context, at least at the current stage. This issue is reflected in Chapter 5, in which local community leaders could not diffuse their interventions to the community, resulting in community members being unaware of efforts targeting childhood obesity.

However, few local leaders interviewed acknowledge the complexity of obesity, but the work of LAs does not indicate that this acknowledgement has been translated into addressing childhood obesity. This finding is consistent with previous international research that found complexity is rarely understood or applied literally.⁴⁶²⁻⁴⁶⁴ For example, a qualitative study exploring how national policymakers in the UK understand and navigate the complexity of PA reported that policymakers have expressed doubts about their grasp of complexity, which might hinder stakeholders' efforts to develop an effective systems-based intervention for PA.⁴⁶² Similarly, a British study was conducted to understand how 32 LAs address obesity and found that despite that LAs recognise the complex nature of obesity, around two-thirds of LA's policies focus on individual behaviours.⁴⁶⁴

Another critical role of local leaders in obesity prevention is to increase community engagement in designing and delivering systems interventions.^{238,239} Within the Saudi context, there is a lack of community engagement and involvement in addressing childhood obesity based on the views of key informants and DMs. This finding aligns with a number

of international studies that highlighted the limited use of the community engagement approach in public health in non-Western settings.^{465,466} Considering the importance of community engagement in a CBSA and its role in sustaining obesity prevention,^{333,392} the feasibility of applying CBSA in Saudi is questioned, at least at the current stage. Before adopting a CBSA, it is important to gain community buy-in to instil confidence among local leaders.⁴⁶⁷ Moreover, community engagement is essential during the whole process of applying systems-based obesity interventions to further strengthen community capacity and ownership.^{233,348}

Optimistically, interviewees pointed out the political will at a national level to address obesity and its comorbidities by implementing taxation and planning for several upcoming policies, such as controlling advertisements directed to children. In 2017, the country began taxing energy drinks at 100 % and soft drinks at 50 %, higher than the recommended taxation of 20%. Notably, taxation was introduced after the drop in oil prices in 2016 and as an implementation of Saudi vision 2030, which may clarify the drive behind this taxation as a part of the diversification of the country's economy.⁴⁶⁸ However, taxation alone may not be a solution to address obesity in the country. For example, a repeated cross-sectional Saudi study examining the differences between pre- and post-tax implementation among 453 children aged 12 to 14 years found no statistically significant impact of taxation on Saudi children's consumption of sugary and energy drinks.⁴⁶⁹ Regardless of the drive behind the taxation, it is widely seen as a significant win for the country's public health. Moreover, the political will, regarding public health and obesity, in particular, is stated in the Saudi vision 2030. This PhD study found that LAs have started dismantling and creating new departments to enhance and promote health within their community. However, the roles of these new departments within LAs are not established explicitly yet.

Another aspect of the political will is illustrated through several recently launched programmes to achieve Vision 2030's health-related objectives. In 2020, the QoL programme was launched to enhance the environment and introduce new opportunities for Saudis to participate in physical activity. Additionally, the national transformation programme was established to promote health and control NCDs and promote health in policies and a better cross-sectoral collaboration at the state and local levels.^{470,471} With the recent massive shift in government operations towards achieving the 2030 vision, there is enormous anticipation that the 2030 vision might help address several challenges that may improve applying the CBSA to childhood obesity prevention.

8.4.3 Collaboration

Taking a systems approach to obesity prevention has various policy implications that demand action from several sectors and go beyond those immediately related to health.⁴⁷² In addition, such an approach also requires looking at the "wider context" and ensuring that key actors are aware of this and do not simply focus on their area.⁴⁷³ Clearly, systems working is enabled by collaboration and long-term relationships among relevant authorities and organisations. However, this thesis demonstrated a clear lack of collaborative efforts to address childhood obesity in the Saudi case. This finding aligns with the Saudi literature, which demonstrated a lack of collaboration among sectors to address NCDs.^{253,474} Moreover, this thesis demonstrated that most obesity prevention efforts are run under the power of the MOH. This observation is also in line with the finding of the WHO-EMRO that reported the role of non-health sectors is underdeveloped in nutrition-related policies and interventions.⁴⁷⁵

This lack of collaboration may be partially attributed to ineffective leadership, as described in section 8.4.2. A review of barriers and facilitators of collaboration to take on complex

health issues indicated that a lack of effective and strong leadership impacts the collaboration outcomes among different sectors.⁴⁷⁶

Effective collaboration is attributed to several factors, including unambiguous roles among authorities.⁴⁷⁶ Within the Saudi case, roles and responsibilities among LAs seem to be overlapping regarding childhood obesity prevention. This finding is consistent with Saudi public health literature that emphasises the need to clarify the roles and responsibilities of authorities to successfully address public health issues, including childhood obesity.^{253,474} As an example of overlapping roles, Chapter 6 found that the same roles, such as issuing guidelines and strategies for addressing childhood obesity, are assigned to more than one governmental agency.

Furthermore, continuous communication among sectors and systems with a shared goal is essential when taking a systems approach.⁴⁷⁷ Consistent and strong communication among authorities are critical to ensure the spreading of knowledge changes among actors, resulting in a system-level change.⁴⁷⁸ However, based on DMs' views, this kind of communication does not exist among LAs. This finding is in line with the latest report of the World Obesity Federation in 2021, in which the Saudi Public Health Authority acknowledges the lack of clear and unified communication strategies between key Saudi authorities and organisations.⁴⁷⁴ In addition, effective communication among relevant entities is a documented issue in Gulf countries. For example, a qualitative Emirates study exploring the perception of 29 policymakers from different authorities regarding school nutrition programs reported limited communication among relevant stakeholders due to a lack of roles and responsibilities.⁴⁷⁹ This issue constitutes a fundamental barrier, given the importance of communication among relevant parties when applying the CBSA. Therefore,

Saudis must develop clear communication plans across involved entities to improve the feasibility of taking the CBSA.

This lack of collaboration, accompanied by a lack of long-term communication and overlapping roles and responsibilities, might be problematic for applying CBSA since the literature on systems interventions emphasises the need for joint efforts across all sectors to address obesity. Moreover, another critical issue is designing and delivering obesity prevention efforts under one body and in isolation from other bodies. For example, many policies and actions aimed at addressing childhood obesity, such as city planning, fall beyond the authority of the MOH, necessitating the need for collaboration and coordination among governmental and non-governmental authorities and organisations. This urgent need is aligned with the call from the WHO-EMRO to develop a multisectoral action plan including all relevant sectors to scale up the prevention and control of NCDs in the region.⁴⁸⁰

8.4.4 Partnership with the private sector and NPOs

Engaging the private sector, such as the food and beverage industries, to address public health issues, including childhood obesity, is a dilemma. However, systems approach experts and literature recommend engaging the private sector.^{205,481} The findings of Chapter 4 are in support of this recommendation because the included programmes engaged private sectors. However, from the perspective of DMs, there is an absence of engaging private sectors in addressing childhood obesity nationally and locally in SA. This finding might be surprising when knowing that local DMs recognised the importance of engaging private sectors in the fight against childhood obesity. DMs revealed a tendency of the central government to disengage the private sector in addressing public health issues. This tendency may appear through arduous procedures and bureaucracy to initiate a

partnership accompanied by delaying approvals. This finding is aligned with a Saudi cross-sectional study investigating barriers to a public-private partnership among 72 stakeholders in the health sector. The study found that delays in approving public-private partnerships were considered the most significant impediment to a public-private partnership.⁴⁸²

This lack of private sector engagement seems a concerning issue when considering the CBSA for obesity prevention. The private sector, specifically the food industry, is a critical actor who has a vital role in addressing obesity. International institutions and Arab experts in obesity prevention research have frequently asked for more involvement with the private sector to alleviate malnutrition in low-middle-income countries.^{258,483-485} In addition, the WHO-EMRO call for advocacy of the private sector in order to prevent and control NCDs in the Eastern Mediterranean region.⁴⁸⁰

The partnership with the private sector should consider the significant political influence that the corporate food sector can generate. For example, the sugary drink industry in 2016 spent around 50 million to advocate against the US efforts to lower soda intake.⁴⁸⁶ Studies sponsored by this industry are five times more unlikely to identify associations between obesity and sugary beverages than other research.⁴⁸⁷ The sugar industry has purposely used and funded research to obscure the link between these beverages and coronary heart diseases.⁴⁸⁸ As a result, Saudi authorities should consider these challenges before entering into a partnership with the food industry, particularly giant food corporations. Private sectors, including the food and beverage industries, might have to disengage if they fail to align with the vision and goals regarding childhood obesity prevention before the relationship becomes a liability.⁴⁸⁹

On the other hand, there is less attention paid to NPOs. Most DMs interviewed did not discern the influential role of NPOs in addressing childhood obesity. This finding is

consistent with those from Saudi studies on the role of NPOs within the Saudi community,^{490,491} and fits with the frequent call of the WHO-EMRO to facilitate and empower the participation of NPOs in NCDs in the region.⁴⁹²

This lack of contribution from the NPOs might be concerning given their roles in filling voids often not addressed by governmental or private sectors, such as demanding political will regarding childhood obesity prevention.⁴⁹² Additionally, Chapter 4 demonstrated that programmes that have comprehensively used the systems approach relied partly on NPOs. In addition, NPOs have a vital role in addressing public health issues when included as DMs. For example, NPOs played a crucial role in Brazil's and Fiji's food policies, including establishing agendas, attracting attention, formulating policies and garnering political commitment.^{493,494} Finally, considering the loss of the role of NPOs in SA raises concerns regarding the successful application of the CBSA to obesity prevention. Saudis are advised to strengthen the engagement of NPOs in obesity prevention, as this engagement encourages systemic shifts and exerts pressure on all levels for action.²⁰⁵

8.4.5 Capacities of local authorities

Using the CBSA to address obesity goes beyond effective leadership, collaborative efforts and partnerships. The capacities of LAs are crucial to maximising the benefits of using the CBSA. Building community capacity is vital to ensure the success of applying a systems approach to ensure the ownership and sustainability of prevention activities.⁴⁹⁵ Unfortunately, from the perspective of DMs, there are several barriers related to the capacity of the local community. First, a lack of and/ or insufficient financial resources among LAs was identified as one of the main barriers to taking the CBSA to develop childhood obesity prevention interventions. This finding supports the findings of a cross-sectional Eastern Mediterranean study of 62 policymakers representing various authorities

and organisations.⁴⁰⁷ The study identified financial resources as a major barrier to using the systems approach in the health sector.

Second, DMs revealed that Saudi LAs suffer from weak capacities, such as a lack of public health experts and a lack of planning to address public health issues, resulting in short-term and fragmented prevention efforts. Similarly, a recent mixed-methods Saudi study involving public health-related authorities and faculties to investigate the needs and availability of public health workforce and education programmes found a scarcity of competent public health workers in the country.⁴⁹⁶ Moreover, these findings align with a review conducted by the WHO-EMRO regarding challenges to implementing the WHO policies and interventions for a healthy diet.⁴⁷⁵ The review found that most Eastern Mediterranean countries reported a shortage of human capacity. In addition, health promotion efforts in SA require a much-needed boost, but the country's public health experts are presently in short supply.⁴⁹⁷

However, few DMs who participated in this PhD study indicated that a request had been made to establish a public health fund to overcome financial issues, which may strengthen the capacity of LAs. This might be considered a significant move toward securing the financial resources needed for addressing complex public health issues. In addition, investment in public health can also be cost-effective and cost-saving.^{498,499} For example, a systematic review of 52 studies in developed countries published over four decades to determine the return on investment in public health reported that an average of £14 will be returned to the economy of the broader health and social care for every £1 spent in public health.⁵⁰⁰ Furthermore, Saudi LAs should consider other strategies, including external funding and reorienting current systems. For example, the local community should focus

on reorienting current resources, such as changing the menu in schools or other children's centres to be healthier, instead of establishing a new grant-funded programme.

A further challenge identified by DMs related to LAs' capacities is the lack of local and national data on childhood generally and childhood obesity specifically. Accurate data collected over a long period at frequent intervals, high response rates and timely feedback are vital to support preventative initiatives.⁵⁰¹ For example, the WHOSTOP used a monitoring system that constructed high-quality childhood monitoring data to support the process of the system boundary.¹ This kind of surveillance system has not been developed for national or local Saudis. This finding is in line with an Eastern Mediterranean study exploring the burden of obesity that reported the urgent need for a high-quality surveillance system on obesity and risk factor.⁵⁰² A Lancet report on the actions and needs of the Arab world in response to the NCDs crisis stated that the capacity of authorities in Arab countries to construct surveillance and provide actors with timely data required for policy planning and evaluation varies substantially among nations and is typically insufficient.⁵⁰³ According to the WHO-EMRO, many countries in the region need support to establish or strengthen their surveillance systems to monitor childhood obesity.⁵⁰⁴

However, the issue of childhood obesity surveillance and monitoring is not specific to this region; it is a global issue. An international call for policymakers has been made frequently to put the public health surveillance system in place.⁵⁰⁵⁻⁵⁰⁸ Within the Saudi case, this lack of a surveillance system on childhood obesity may hamper planning measures within LAs and making the use of localised or even nationalised data to understand behavioural differences unfeasible.¹ Noteworthy, this lack of data is accompanied by a lack of research (described in detail in section 8.4.1), undermining the feasibility of applying the CBSA to obesity prevention.

A key feature of taking the systems approach to address complex public health issues is the ongoing monitoring of actions. Monitoring the progress of systems change can identify areas where actions are not functioning effectively and which should be amended or discontinued and speed up operations that are performing well.⁴⁸⁹ Additionally, greater monitoring of obesity-related environments, systems and policies is required to ensure that major actors are held accountable for coordinated actions.²⁰⁵ However, DMs highlighted a severe weakness in the monitoring capacity of governmental agencies. This finding is in line with that of a recent review aimed at providing an overview of current dietary fat policies in eastern Mediterranean countries, which revealed the need to monitor policy implementation and analyse its effect.⁵⁰⁹

Considering the critical role of ongoing monitoring, taking the CBSA to develop childhood obesity within the Saudi community could be challenging. Weakness in monitoring capacity might be addressed by developing a comprehensive monitoring mechanism and increasing investment in monitoring capacity at multiple levels. NPOs can play a vital role in strengthening monitoring capacity. Therefore, mobilising and engaging NPOs in childhood obesity prevention may help address some weaknesses that Saudi governmental agencies face.

A further core challenge identified in this PhD study is the high centralisation in decision-making and planning related to childhood obesity prevention among governmental authorities. To achieve a system-wide change, decision-making and implementation should be decentralised.⁴⁸⁹ In fact, SA is characterised as a highly centralised country with many duties conducted at the local level by divisions of the central government. This high centralisation has impeded LAs from tailoring interventions that meet the local community's needs. For example, LAs have no right to start an initiative for childhood

obesity prevention without approval from the central government. Moreover, a major consequence of high centralisation is the lack of freedom among LAs to collaborate and partner with other bodies and even participate in community-based research.

This high centralisation among Saudi LAs might pose a challenge to taking the CBSA in developing obesity prevention interventions. Centralisation of power may impede progress and limit the degree to which authorities can shape their decisions. In addition, centralised governance can impede collaboration, a fundamental component of CBSA, among LAs to address childhood obesity. For example, the centralisation of the Ecuadorian government hampered the role of key players, such as civil society, in developing a community-based approach.⁵¹⁰ Moreover, centralisation may hinder policy decision-making in obesity prevention. For example, the UK government introduced a localism policy agenda in 2011 to shift power and decision-making from central to local governments to deliver public health and other services to local areas.⁵¹¹ This act was enacted to increase accountability and local decision-making, allowing different ways of local authority working and structure, removing aspects of central oversight, and giving local areas more freedom over planning decisions.

Decentralisation in the decision-making and planning of public health is required within the Saudi community before deciding to take the CBSA. This decentralisation may give LAs greater freedom to formulate policies, act and respond to childhood obesity based on their local community needs. However, a rush decentralisation of power is not advocated since it often leads to weak, disorganised, ineffective, and understaffed LAs.²⁰⁵

8.4.6 Systems thinking capabilities

Applying a successful systems approach requires developing systems thinking capabilities among stakeholders with varying educational and professional backgrounds.⁵¹² Inadequate

capabilities of DMs may hinder the adaptation and application of the systems approach.⁵¹³ Unfortunately, this study found a lack of knowledge of CBSA among local DMs. Understanding the CBSA to childhood obesity prevention was a new way of thinking for all DMs (except one DM who is highly trained in public health) interviewed in this PhD study. This finding is consistent with the finding of a cross-sectional study involving 62 Eastern Mediterranean policymakers that found a lack of knowledge and understanding of the systems approach is a barrier for using it in the area.⁴⁰⁷ This lack of understanding of systems-based intervention is evident in several countries. For example, a qualitative study with 72 stakeholders involved in developing and implementing the *Healthy Town Programme* in the UK reported a lack of understanding of a systems-based intervention among the various stakeholders involved. As a result, stakeholders relied on traditional approaches to develop and deliver interventions rather than CBSA.⁵¹⁴ Moreover, a qualitative study exploring health policymakers' views regarding understanding and applying systems thinking found that those policymakers who claimed systems thinking goes beyond repackaged health promotion failed to describe the difference properly.⁵¹⁵ Hence, educating and training Saudi DMs regarding applying the CBSA and how it differs from traditional risk factors approaches is recommended. This would ensure the successful application of systems-based interventions and not revert to implementing a 'business as usual' approach.

A further challenge related to local DMs' capabilities is the lack of experience in systems practice. Recognising boundaries is one of the most crucial processes when taking the CBSA. DMs who are inexperienced in CBSA may face a challenge in defining system boundaries. They may include non-essential and/or extraneous elements or omitting crucial components and interactions.⁵¹⁶ Moreover, the lack of experience in CBSA among the HTV workforce faced a challenging start. It resulted in increasing temptation to use

traditional prevention approaches instead of using new CBSA methods.^{409,517} However, systems thinking capabilities such as experience are developed over time. For example, those classified as inexperienced systems thinkers were consistent with systems practice and developed a system mindset over time.^{410,518}

Since using CBSA for obesity prevention represents a significant break from past practice within the Saudi community, there is a need to develop the capabilities of CBSA among the workforce, particularly among local leaders across all levels and sectors, into systems thinkers. Notably, systems science techniques are relatively new to the Saudi community. In particular, even local DMs with a health background were unfamiliar with systems work. Therefore, embedding those techniques with an example of applications and providing professional development in systems practice to the local workforce is a way to overcome issues related to systems thinking capabilities.

8.5 Limitations and strengths

Several limitations and strengths have already been covered previously within relevant chapters. However, overarching limitations and strengths are discussed here. The following limitations and strengths are related to the research as a whole.

8.5.1 Limitations

The first limitation relates to the pre-specified LAs and other relevant organisations participating in this research. I selected these authorities/organisations based on my prior knowledge and work experience in the local community. Although an extensive review was conducted to identify the providers of the pre and current efforts to address childhood obesity in the community, such efforts lacked detailed information about providers. This may have resulted in a tiny probability that the voices of certain national or LAs were not

approached and included in this research. Therefore, the views expressed in the current thesis are limited to those who participated in the research.

An additional weakness is related to the participants themselves. Although high-level DMs were asked to attend, few middle-level representatives were nominated to represent them. This might have influenced the degree of representation of participants in this thesis. Those senior-level DMs could not participate in the study as they were working in the governmental health sector that was busy due to COVID-19, so they nominated their deputies to participate. In addition, this representation issue might have also influenced the accuracy of the information gained from those few mid-level representatives. For example, deputies may have less knowledge and understanding of facilitators and barriers or any new action plans targeting childhood obesity in their area than senior DMs.

A further limitation related to the participants is that all participants were officials from the highest levels of the Saudi government and sparse representation from members of private and NPOs sectors. This may raise a concern about a lack of public voice (lay people) regarding the use of CBSA within the Saudi community. Lay people such as parents, children and others who do not hold a leadership role within the Saudi community were not involved in this study since they were unexpected to understand the larger community's situation comprehensively. Despite how unlikely it seems, there might be some constraints or opportunities for using CBSA within the Saudi community that the present participants were unaware of. Therefore, the views expressed in the current thesis are limited to those DMs and leaders who participated in this research.

A critical limitation of this study is related to generalisability. The findings may not be significant to other countries even if they have some comparable circumstances to the Saudi community. However, choosing Makkah city -the second-largest populated city- as a

reference for the whole country may not affect the generalisability of this study. This is because there are no radical differences among cities in SA at the hierarchical level. All governmental agencies participating in this research have centres/branches in most cities of SA, and they operate and are managed in the same way. In addition, recruitment criteria are standardised in the governmental sector in the country, which means all authorities and agencies reproduce the same capacities and capabilities.

Notably, this research was conducted when a few LAs and other relevant organisations were undergoing restructuring as part of achieving Saudi's Vision 2030. This vision targets changes in governmental authorities, including structural and financial change, building institutional capacities and developing mechanisms of collaboration and partnership with other sectors. This may have led to a few DMs not ascertaining the continuity of the current or past challenges regarding addressing public health issues, including childhood obesity.

A further weakness of this research is the small number of participants representing the private and NPO sectors in the study. Engagement of these two sectors is advised for systems-level changes.²⁰⁵ However, although there was a great effort to recruit representatives from these sectors, there was a lack of desire to participate from these two sectors for many reasons. The most important reason was the lack of a current or previous role in addressing childhood obesity within the community. This might have led to a lack of in-depth understanding of the feasibility of the CBSA from the perspective of the private sector.⁴⁸⁹

Another limitation is the researcher's interpretation of results, which is common in many qualitative studies conducted by a single researcher. However, the researcher ensured that all findings were addressed with a supervisory team and challenged to ensure that they were based on the actual data rather than unsupported interpretations. In addition, the

researcher was aware of his reflexivity in all stages of the research (described in detail in Chapter 5) and increased transparency regarding the whole research process, which mitigated further the potential bias.^{519,520}

Finally, interviews and GMB session were conducted remotely. Some technical issues were witnessed, ranging from postponements in transmission across the internet to complete loss and the necessity to reinstate the communication. Furthermore, most interviewees preferred not to turn their cameras on during the interviews, possibly losing some of the participants' body language.

8.5.2 Strengths

A significant strength relies on the main aim of this study- to examine the feasibility of using the CBSA for obesity prevention in a non-western, developing setting. This question was investigated through different perspectives and work packages. These work packages included synthesising Saudi evidence based on childhood obesity, assessing the community's readiness for childhood obesity prevention, exploring views of DMs regarding using the CBSA for childhood obesity prevention, and finally, testing and identifying issues related to the recruitment and operational processes of a GMB workshop. Strengths rely on the new insights offered by this PhD study regarding applying the GMB approach to a non-Western setting since all previous GMB studies were undertaken in Western settings.

A further strength is successfully recruiting nearly all relevant obesity prevention LAs and various relevant parties, e.g., governmental, private and NPOs. This recruitment was restricted to predefined criteria, ensuring that participation in this study was limited to those directly influencing children's environments. This allowed me to understand the context from the broadest perspectives. Finally, I am a Saudi national living in the same city as the

study participants. However, this is double-edged; it can strengthen the study and mould the researcher into any social, environmental or political aspects, but also it might bring weakness to the study in which the researcher's background and assumptions about the community may affect the study findings.⁵²¹ However, this issue was addressed through awareness of reflexivity (described in detail in Chapter 5).

8.6 Recommendations

The following subsections summarise the recommendations based on this PhD study. In particular, the recommendations relate to improving the feasibility of applying the CBSA to developing childhood obesity prevention interventions within the Saudi community. The recommendations are divided into five sections: central government, local government, NPOs, private sector and research.

8.6.1 Recommendations for central government

The findings from this research have some implications for the Saudi national government. First, a significant issue identified by local DMs related to the national government is the financial allocation. To address this financial gap, advocacy efforts should be carried out to mobilise the Saudi national government to increase financial allocation to address public health issues, including childhood obesity, to all LAs involved. It might be necessary to raise awareness of the central government that addressing childhood obesity leads to significant economic gains for the whole country. Moreover, no information is available regarding public health allocations. Saudis are recommended to develop a sustainable financing system that acknowledges differences in financing formulas. This could be done by establishing a public health fund, for example, using SSB tax revenues, and reinvesting the revenue into the public health fund.

Second, having few authorities that produce almost identical functions might not be sustainable.⁵²² Therefore, an important step to improve the feasibility of using CBSA is to precisely demarcate the role and responsibilities among LAs. The current situation is characterised by overlapping roles/responsibilities, and also, few DMs stated that no roles/responsibility is assigned to their authorities. Preventing childhood obesity on a population level requires clearly defining who is responsible for what.⁵²³ This demarcation should also clarify the roles of private and NPOs in terms of childhood obesity prevention.

A further implication to the central government is to decentralise power regarding public health issues from a national to a more local level. Transferring public health responsibility to LAs may present an excellent opportunity to combine public health professionals' expertise and skills with other authorities' capacities. The government must make the most of this chance to improve the well-being of people in a systemic way. This decentralisation should also extend to decision-making processes, allowing LAs to innovate, lead, and control essential choices. Furthermore, the central government should also leave the decision to partner with private and non-profit sectors to the LAs after clarifying the roles these two sectors can play in addressing public health issues. Moreover, there should be an encouragement of collaboration among governmental LAs in response to local needs and create a space for private sectors and NPOs.

A further implication is the need to prioritise childhood obesity prevention among LAs. Notably, national authorities seem to have the will to address obesity within the country. However, this will is not reflected at the local level. Childhood obesity is a real issue that must be addressed by coordinating efforts across all authorities, and the will of the central government must be reflected in local governments. An essential task would be to establish and strengthen relationships among local and national authorities and other partners such

as municipalities and education to translate the national will into action on the ground. Failing to do so will have severe repercussions for both children and the economy, considering the country's high levels of childhood obesity.

An additional recommendation to the Saudi government is to construct a national database of childhood obesity, including risk factors, to identify and prioritise areas of concern. This could be achieved by carrying out a national survey like those in developed nations to collect data related to anthropometric measures and associated risk factors. The national survey should not focus only on individual risk factors but only delve deeply into policy, community and environmental risk factors. Furthermore, this national database should be collected accurately so that it can be used in part to inform funding allocations. In addition, sharing and making findings accessible to all sectors, including academia, is advisable.

8.6.2 Recommendations for local government

This research has several implications for the local government. First, this research emphasises the need to effectively build capacity among LAs to address childhood obesity. This would be done by ensuring the local community's needs and priorities are understood by all authorities, increasing funding allocation for childhood obesity prevention and providing human resources (public health experts).

A further action area to improve the capacity of LAs is to construct local data on childhood obesity to support the planning process and identify areas of concern. Moreover, there is a need to strengthen monitoring and evaluation capacity in all development processes, from planning to delivering among LAs, to support the decision-making process regarding childhood obesity prevention. This would be done by partnering with other governmental authorities, local universities, and private/NPOs sectors. All strategies and policies that impact childhood obesity should be evaluated and monitored proportionately. In addition,

LAs are urged to allocate appropriate time and resources to the evaluation process and ensure that the findings are accessible to all those who potentially benefit.

A further implication to the local government is to develop systems thinking capabilities among local workforces. This would be done by investing in fostering systems practice among LAs and providing training to local DMs on understanding the application of the CBSA to obesity prevention. Considering the complete lack of knowledge and experience in the participatory approach among local DMs, more detailed training on the CBSA would be beneficial. In addition, local universities and education centres could contribute to building capabilities by training future leaders in systems modelling and offering more comprehensive programmes and degree options.

A significant implication to the local government is to convene a new coalition and build a long-term collaborative relationship and network with prevention partners. This prevention partnership should have a knowledge exchange, continuous communication, and coordination to achieve systemic change. In addition, Saudis are advised to establish a leadership group by identifying and engaging community leaders, ensuring that the role of the leadership group is understood and that the right leaders/authorities with local influence are recruited. This new coalition would be done by breadth-identifying partners from all sectors and levels who have the capacity to affect drivers of childhood obesity. Doing so will likely give a complete perspective of the system of childhood obesity in the community, identifying the best actions aligned with local resources and capacity.

8.6.3 Recommendations for NPOs and private sectors

Findings from this research have a few implications for the Saudi NPOs and private sectors interested in preventing NCDs. A first recommendation is to build relationships, social networks and trust with LAs and community members. This would be done by conducting

symposiums, workshops and conferences on childhood obesity or related issues. In addition, those NPOs that are financially able to support research related to childhood obesity should do so. A further implication for both sectors is to help build the capacity and capabilities of LAs regarding childhood obesity prevention. This would be done with the help of establishing the surveillance systems and undertaking an evaluation of programs/practices/policies to inform the evidence base. In addition, it is advisable to fund and provide training for DMs on applying the CBSA to obesity prevention. This would be done by introducing DMs to systems science through various tools such as GMB workshops.

8.6.4 Recommendations for further research

Several implications for future research flow from this thesis around childhood obesity prevention in SA, including:

- a) The need for a holistic perspective on childhood obesity etiological research in SA using a high-quality study design that focuses on policy, community and environmental determinants rather than individual determinants.
- b) Shifting from linear to non-linear thinking using systems science approaches and tools to investigate what factors might have a role in the development or prevention of childhood obesity and how these factors might change and interact together over time as a dynamic system(s).
- c) Conducting a full-scale GMB workshop considering recommendations reported in Chapter 7 will likely arise new opportunities for the most culturally appropriate way to run GMB workshops within the community.
- d) Understanding the reasons for the lack of collaboration and coordination across LAs and elements that may contribute to better collaboration and coordination.

- e) Understanding the reasons for the lack of engaging private and NPOs sectors in addressing childhood obesity.
- f) Developing a better knowledge and understanding of the role of national authorities and their relationship with and influence of LAs in addressing childhood obesity prevention.
- g) Evaluating and monitoring current and past childhood obesity-related efforts to understand their impact.
- h) In-depth understanding of relevant authorities' organisational capacity, leadership, and systems thinking capabilities across obesity prevention and other NCDs.
- i) Examining the use of evidence and the actual decision-making processes in LAs when addressing public health issues, including childhood obesity.

8.7 Contributions to the literature

This thesis adds to the knowledge base of childhood obesity prevention by presenting a great depth and nuanced understanding of *why* taking a systems approach to developing childhood obesity prevention intervention in a non-Western, highly centralised country requires much prior work. Furthermore, as one of the first known studies to look at various aspects of systems-based obesity prevention in a non-Western setting, the results offer rich insight into facilitators and obstacles of the systems approach and how policymakers can enhance the use of such an approach.

Although international obesity experts and the latest research recommend using a systems approach to tackle complex public health issues, including obesity, this study confirmed that SA needs much work to improve the feasibility of using this approach to develop childhood obesity prevention interventions or other public health problems. This study confirmed the importance of assessing the feasibility of applying such an approach to

address a complex public health issue in countries considered highly centralised governments. By exploring factors that hinder or facilitate using the systems approach in those countries, areas of improvement can be identified and developed to enhance practical application. For example, systems thinking capabilities are relatively important in applying SA to obesity prevention. Therefore, it is more important to investigate those capabilities as they represent opportunities and threats for using the systems approach in SA. Without an in-depth understanding of those capabilities, using a systems approach to developing childhood obesity prevention interventions is unlikely to produce the desired systemic change. While this approach has been used in Western countries, appropriate adaptation might be required for non-Western countries. This study provided the first example of *what* areas need improvement to enhance the use of a systems approach to developing childhood obesity prevention interventions in non-Western countries.

The scoping review of a comprehensive application of the systems approach to obesity prevention helped identify the need to develop guidance for reporting systemic obesity interventions using SAP. One of the important findings of the scoping review was that poor reporting might partly explain why only a small number of studies met the inclusion criteria, which led to the idea of developing practical guidance for the reporting, reviewing and evidence synthesis of authentic systemic work in obesity prevention and any other public health issues. This guidance was designed by senior academics with empirical, systemic work in many countries and presents an early step towards establishing more comprehensive guidance for reporting systemic public health interventions as more empirical evidence becomes available.³²⁵ This guidance is expected to help editors, researchers and reviewers to assess articles reporting public health interventions using a systems approach and help clarify what authentic, comprehensive application of systemic work involves in practice.

Furthermore, this is the first known study investigating multiple aspects of childhood obesity in SA, including a synthesis of the literature on modifiable risk factors, the community readiness to address childhood obesity, DMs' views regarding the use of the systems approach and finally, practical issues related to the use of GMB within the Saudi community. These investigations produced an in-depth understanding of childhood obesity prevention in this country. Therefore, the findings of this study can be used as a blueprint to guide future childhood obesity research and policy-making in SA, particularly where there is a lack of research in these areas.

8.8 Dissemination plan

Local and national authorities participating in this research will be informed of the findings. Final reports will be distributed to DMs who participated in the study to overview the possible ways to systems change and prevent childhood obesity. In addition to informing the necessary offices of the results, making this study available to relevant authorities will also guide other investigators interested in investigating childhood obesity in SA. Some parts of this thesis (systematic review, scoping review and the CRM) are under consideration in peer-reviewed journals. The scoping review and the study in Chapter 6 were presented at two different conferences. In addition, a number of DMs also asked me to conduct a presentation on using CBSA to address childhood obesity in SA. The repository of the University of Bristol will also include this work.

8.9 Conclusion

Preventing and addressing several public health issues, such as childhood obesity, is quite challenging because of their complexity. So, public health literature is increasingly acknowledging the importance of using systems-based prevention interventions to address the complexity of childhood obesity. A few empirical studies have recently tried to apply

the CBSA to public health interventions to replace traditional approaches that use simple and/or multi-setting interventions. However, all those studies are centred on western populations, indicating research gaps regarding the feasibility of applying the CBSA to tackling complex public health issues in non-Western populations.

This thesis aimed to assess the feasibility of applying the CBSA to developing childhood obesity prevention interventions in SA. Different work packages were conducted using systematic reviews and qualitative and GMB approaches. This thesis confirmed the importance of assessing the feasibility of applying the CBSA to developing obesity prevention interventions in non-Western populations, particularly those with highly centralised governments.

Findings demonstrated that several areas need to be improved before Saudis can successfully apply a systems approach to tackling childhood obesity. These areas include weaknesses surrounding the current evidence-based, ineffective leadership, lack of collaboration and partnership, and severe weakness of the capacities of local authorities and systems capabilities of the workforce. Therefore, this research recommends that the next step should be targeting these areas to improve the feasibility of taking systems-based interventions in Saudi Arabia.

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Appendices

Appendix 1: Search strategies

1- MEDLINE

Database(s): **Ovid MEDLINE(R)** 1946 to January Week 3 2019

Search Strategy:

#	Searches	Results
1	(Obes* or overweight or adiposity or body weight or body mass index or BMI or fat* or weight).ti,ab.	1497932
2	Obesity/ep, eh, et, pc [Epidemiology, Ethnology, Etiology, Prevention & Control]	53984
3	"Body Weights and Measures"/	6015
4	("physical activity" or "physical inactivity" or exercise or fitness or "physical exercise" or sport or walking or running or swimming).ti,ab.	418120
5	exp Exercise/	173718
6	1 or 2 or 3	1507493
7	(diet or nutrition or "food habit" or "eating habit" or "eating behavior*" or "eating attitudes" or "dietary intake" or food or drink or beverages or "fast food" or sugar or "unhealthy food" or "sugars-sweetened" or "soft drink" or "SSBs" or "sugary drinks").ti,ab.	716904
8	exp Feeding Behavior/	157659
9	exp "Feeding and Eating Disorders"/	28454
10	(sleep or "sleep deprivation" or "sleep disturbance" or "sleep quality" or insomnia or "sleep difficult*").ti,ab.	134666
11	exp Sleep/	73771
12	("sedentary lifestyle" or "sedentary behavior*" or inactivity or "screen time" or technology or computer or PC or tablet or "mobile phone" or smartphone or internet or "electronic devices" or "video games").ti,ab.	502577
13	exp Sedentary Behavior/ or exp Screen Time/ or exp Video Games/ or exp Television/	41706
14	("socioeconomic status" or SES or poverty or income or salar* or "social class" or "social status" or socioeconomic).ti,ab.	175352
15	exp Socioeconomic Factors/	419923

16	(job or employ* or work* or career or occupation or affluent or rich* or wealth* or housing or home or accommodation or residen*).ti,ab.	2014251
17	demography/ or population/	65333
18	(stress or anxiety or depression or "depressive disorder" or "depressive symptoms" or "mental health" or "mental illness" or "mental disorder" or "psychiatric illness").ti,ab.	964737
19	exp depression/ or exp stress, psychological/	214737
20	(risk factor* or "contribut* factor*" or "predispos* factor*" or "influenc* factors" or determin* or predictor or caus*).ti,ab.	4983511
21	exp causality/ or exp precipitating factors/ or exp protective factors/ or exp risk factors/	764541
22	(child* or adolescen* or teen* or youth or "young people" or paediatric or pediatric).ti,ab.	1400102
23	("school age" or school* or "school aged children" or "school-age" or "school-aged" or student* or pupil* or learner*).ti,ab.	403790
24	exp child/ or exp child, preschool/	1805862
25	exp Schools/	108655
26	4 or 5 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21	8653744
27	22 or 23 or 24 or 25	2557008
28	6 and 26 and 27	132660
29	("SA" or saudi or KSA).ti,ab.	12230
30	exp SA/	11538
31	29 or 30	14555
32	28 and 31	432

2- PsycINFO

Database(s): **PsycINFO** 1967 to January Week 3 2019

Search Strategy:

#	Searches	Results
1	(Obes* or overweight or adiposity or body weight or body mass index or BMI or fat* or weight).ti,ab.	185129
2	exp obesity/ or exp overweight/ or exp adipocytes/ or exp body mass index/ or exp "obesity (attitudes toward)"/	27268
3	("physical activity" or "physical inactivity" or exercise or fitness or "physical exercise" or sport or walking or running or swimming).ti,ab.	117912
4	exp exercise/ or exp physical activity/ or exp physical fitness/ or exp weight control/	43777
5	(diet or nutrition or "food habit" or "eating habit" or "eating behavio*" or "eating attitudes" or "dietary intake" or food or drink or beverages or "fast food" or sugar or "unhealthy food" or "sugars-sweetened" or "soft drink" or "SSBs" or "sugary drinks").ti,ab.	109007
6	exp eating behavior/ or exp binge eating/ or exp appetite/ or exp diets/ or exp eating attitudes/ or exp eating disorders/ or exp feeding disorders/ or exp food intake/ or exp mealtimes/	66194
7	(sleep or "sleep deprivation" or "sleep disturbance" or "sleep quality" or insomnia or "sleep difficult*").ti,ab.	62512
8	exp sleep/ or exp sleep deprivation/ or exp sleep disorders/	37363
9	("sedentary lifestyle" or "sedentary behavio*" or inactivity or "screen time" or technology or computer or PC or tablet or "mobile phone" or smartphone or internet or "electronic devices" or "video games").ti,ab.	169284
10	exp lifestyle/ or exp active living/ or exp lifestyle changes/ or exp daily activities/	14286
11	exp Childhood Play Behavior/ or exp Screen Time/ or exp Television/	15033
12	("socioeconomic status" or SES or poverty or income or salar* or "social class" or "social status" or socioeconomic).ti,ab.	127456
13	exp SOCIOECONOMIC CLASS ATTITUDES/ or exp FAMILY SOCIOECONOMIC LEVEL/ or exp SOCIOECONOMIC STATUS/	47281
14	(job or employ* or work* or career or occupation or affluent or rich* or wealth* or housing or home or accommodation or residen*).ti,ab.	1003115

15	(stress or anxiety or depression or "depressive disorder" or "depressive symptoms" or "mental health" or "mental illness" or "mental disorder" or "psychiatric illness").ti,ab.	624321
16	exp PSYCHOLOGICAL STRESS/ or exp STRESS/	100999
17	exp Mental Disorders/	559399
18	(risk factor* or "contribut* factor*" or "predispos* factor*" or "influenc* factors" or determin* or predictor or caus*).ti,ab.	723333
19	exp causality/ or exp etiology/ or exp risk factors/	104824
20	(child* or adolescen* or teen* or youth or "young people" or paediatric or pediatric).ti,ab.	780240
21	("school age" or school* or "school aged children" or "school-age" or "school-aged" or student* or pupil* or learner*).ti,ab.	656046
22	("SA" or saudi or KSA).ti,ab.	1897
23	1 or 2	185672
24	2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19	2438640
25	20 or 21	1234333
26	23 and 24 and 25	50233
27	22 and 26	46

3- PUBMED

#20	Add	<p>Search ((((((((((((((((((((((Obes*[Title/Abstract] OR overweight[Title/Abstract] OR adiposity[Title/Abstract] OR "body weight"[Title/Abstract] OR "body mass index"[Title/Abstract] OR BMI[Title/Abstract] OR fat*[Title/Abstract] OR weight[Title/Abstract])) OR (Obesity or Pediatric Obesity[MeSH Terms])) OR (body weights and measures[MeSH Terms])) AND ("physical activity"[Title/Abstract] OR "physical inactivity"[Title/Abstract] OR exercise[Title/Abstract] OR fitness[Title/Abstract] OR "physical exercise"[Title/Abstract] OR sport[Title/Abstract] OR walking[Title/Abstract] OR running[Title/Abstract] OR swimming[Title/Abstract])) OR Exercise[MeSH Terms]) OR (diet[Title/Abstract] OR nutrition[Title/Abstract] OR "food habit"[Title/Abstract] OR "eating habit"[Title/Abstract] OR "eating behavior"[Title/Abstract] OR "eating attitudes"[Title/Abstract] OR "dietary intake"[Title/Abstract] OR food[Title/Abstract] OR drink[Title/Abstract] OR beverages[Title/Abstract] OR "fast food"[Title/Abstract] OR sugar[Title/Abstract] OR "unhealthy food"[Title/Abstract] OR "sugars-sweetened"[Title/Abstract] OR "soft drink"[Title/Abstract] OR "SSBs"[Title/Abstract] OR "sugary drinks"[Title/Abstract])) OR Feeding Behavior[MeSH Terms]) OR (sleep[Title/Abstract] OR "sleep deprivation"[Title/Abstract] OR "sleep disturbance"[Title/Abstract] OR "sleep quality"[Title/Abstract] OR insomnia[Title/Abstract] OR "sleep difficult"[Title/Abstract])) OR intrinsic sleep disorder[MeSH Terms]) OR ("sedentary lifestyle"[Title/Abstract] OR "sedentary behavior"[Title/Abstract] OR inactivity[Title/Abstract] OR "screen time"[Title/Abstract] OR technology[Title/Abstract] OR computer[Title/Abstract] OR PC[Title/Abstract] OR tablet[Title/Abstract] OR "mobile phone"[Title/Abstract] OR smartphone[Title/Abstract] OR internet[Title/Abstract] OR "electronic devices"[Title/Abstract] OR "video games"[Title/Abstract])) OR (Sedentary Behavior or Screen Time or Video Games or Television[MeSH Terms])) OR ("socioeconomic status"[Title/Abstract] OR SES[Title/Abstract] OR poverty[Title/Abstract] OR income[Title/Abstract] OR salar*[Title/Abstract] OR "social class"[Title/Abstract] OR "social status"[Title/Abstract] OR socioeconomic[Title/Abstract])) OR (job[Title/Abstract] OR employ*[Title/Abstract] OR work*[Title/Abstract] OR career[Title/Abstract] OR occupation[Title/Abstract] OR affluent[Title/Abstract] OR rich*[Title/Abstract] OR wealth*[Title/Abstract] OR housing[Title/Abstract] OR home[Title/Abstract] OR accommodation[Title/Abstract] OR residen*[Title/Abstract])) OR (demography or population[MeSH Terms])) OR (stress[Title/Abstract] OR anxiety[Title/Abstract] OR depression[Title/Abstract] OR "depressive disorder"[Title/Abstract] OR "depressive symptoms"[Title/Abstract] OR "mental health"[Title/Abstract] OR "mental illness"[Title/Abstract] OR "mental disorder"[Title/Abstract] OR "psychiatric illness"[Title/Abstract])) OR (depression or stress,psychological[MeSH Terms])) OR ("risk factor"[Title/Abstract] OR "contribut* factor"[Title/Abstract] OR "predispos* factor"[Title/Abstract] OR "influenc* factors"[Title/Abstract] OR determin*[Title/Abstract] OR predictor[Title/Abstract] OR caus*[Title/Abstract])) OR (causality or precipitating factors or protective factors or risk factors[MeSH Terms])) AND (child*[Title/Abstract] OR adolescen*[Title/Abstract] OR teen*[Title/Abstract] OR youth[Title/Abstract] OR "young people"[Title/Abstract] OR paediatric[Title/Abstract] OR pediatric[Title/Abstract])) OR ("school age"[Title/Abstract] OR school*[Title/Abstract] OR "school aged children"[Title/Abstract] OR "school-age"[Title/Abstract] OR "school-aged"[Title/Abstract] OR student*[Title/Abstract] OR pupil*[Title/Abstract] OR learner*[Title/Abstract])) OR (child or child, preschool[MeSH Terms])) OR Schools[MeSH Terms]) AND ("SA"[Title/Abstract] OR saudi[Title/Abstract] OR KSA[Title/Abstract])) OR SA[MeSH Terms] Sort by: Best Match Filters: Publication date from 2018/06/01 to 2019/01/29</p>	459	08:54:23
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4- Web of Science (29/01/2019) at 3:20 pm (232 articles)

ALL FIELDS: (obes* OR overweight OR "body mass index" OR BMI OR "body weight") AND ALL FIELDS: (child* OR adolescen*) AND ALL FIELDS: ("SA" or saudi or KSA) AND ALL FIELDS: ("risk factor*")

Appendix 2: A summary of included studies

Study (1 st author and year)	Study design	Participants (number, age, and sex)	Definition of obesity/overweight	Modifiable risk factors assessed in the study	Key results	Which level(s) of the socioecological model was/were addressed in the study					Quality Score (AXIS)
						Individual	Interpersonal	Environmental	Community	Policy	
Al-Hazzaa (2007)	Cross-sectional	296, 8-12 years, Both	WHO 2000	<ul style="list-style-type: none"> • PA 	<ul style="list-style-type: none"> • Weak negative association between PA and obesity. 	✓	-	-	-	-	75%
Al-Hazzaa (2007)	Cross-sectional	224, 3.4-6.4 years, only males	N/A	<ul style="list-style-type: none"> • PA • TV viewing 	<ul style="list-style-type: none"> • TV viewing negatively associated with obesity 	✓	-	-	-	-	80%
Al-Saeed (2007)	Cross-sectional	2239, 6-17 years, females	CDC	<ul style="list-style-type: none"> • SES 	<ul style="list-style-type: none"> • Children whose moms had advanced degrees and whose dads worked in the private sector were more likely to develop obesity. 	-	✓	-	-	-	70%
Amin (2008)	Cross-sectional	1139, 10 - 14 years, males	IOTF	<ul style="list-style-type: none"> • Breakfast at home • Eating away from home • SES 	<ul style="list-style-type: none"> • Eating out frequently (>3 times per week), low mothers' education, mothers working status, family size and residence are positively associated with BMI. • Having breakfast at home negatively associated with BMI. 	✓	✓	✓	-	-	80%
Khalid (2008)	Cross-sectional	1917, 6-15 years, both	WHO-NCHS	<ul style="list-style-type: none"> • Parental income • Residence 	<ul style="list-style-type: none"> • Moderate to high parental income increased the risk for overweight/obesity. • Born and living at a high altitude increases the risk for childhood obesity. 	-	✓	✓	-	-	70%

Alam (2008)	Cross-sectional	1072, 8-12 years, females	IOTF	<ul style="list-style-type: none"> • Exercise status • Fast food consumption • Soft drink and snack consumption • TV viewing • Mother's working (employment status) 	<ul style="list-style-type: none"> • The frequency of not exercising negatively associated with BMI. • Consuming soft drinks and daily TV viewing positively associated with BMI. 	✓	✓	-	-	-	70%
Al-Alwan (2013)	Cross-sectional	1212, 6-16 Years, both	WHO 2007	<ul style="list-style-type: none"> • SES • School Type (Public VS private) 	<ul style="list-style-type: none"> • Being overweight increases with increased family income. • Level of the mother's education increase obesity risk. 	-	✓	✓	-	-	75%
Al-Ghamdi (2013)	Case-control	397 11-14 years, both	IOTF	<ul style="list-style-type: none"> • No. of meals and snacks/day • Daily exercise (at school, home, outdoors). • No. of TV at home • Child's Ownership of TV • TV viewing at weekend • Using PC and internet 	<ul style="list-style-type: none"> • Around 40% reduction in obesity risk if there is only one TV at home. • BMI increases with a child's ownership of a TV. • Around 19% reduction in obesity risk if watching TV at weekends was reduced by 1 hour. 	✓	-	✓	-	-	80%
Al-Qahtani (2013)	Cross-sectional	197, 9-14 years, males	N/A	<ul style="list-style-type: none"> • Food consuming behaviours • Screen time • PA 	<ul style="list-style-type: none"> • Food-consuming behaviours strongly associated with obesity among children who were described as "eating too much", "arguing if say enough or stop eating", "demanding food while still eating and "demanding food between meals". • PA negatively associated with BMI. 	✓	-	-	-	-	60%

AlMuammar (2014)	Cross-sectional	107,12-15 years, females	N/A	<ul style="list-style-type: none"> • Dietary factors • SES 	<ul style="list-style-type: none"> • No significant associations found 	✓	✓	✓	-	-	60%
Al-Enazy (2014)	Cross-sectional	331, 6-13 years, both	WHO 2007	<ul style="list-style-type: none"> • Screen time • Sleep duration/day • SES 	<ul style="list-style-type: none"> • BMI positively associated with children living with both parents. • Parental education positively associated with BMI. • Maternal working status associated positively with BMI. • Smaller family size (> 6) negatively associated with BMI. 	✓	✓	-	-	-	85%
Al-Shehri (2014)	Cross-sectional	258, 6-12 years, males	N/A	<ul style="list-style-type: none"> • Eating patterns • SES 	<ul style="list-style-type: none"> • Eating fast food at least three times/week positively associated with BMI. 	✓	✓	-	-	-	75%
Alenazi (2014)	Cross-sectional	Confusing (558 or 359), 5-9 years, males	N/A	<ul style="list-style-type: none"> • Having Homemade Breakfast 	<ul style="list-style-type: none"> • BMI (overweight/underweight) negatively associated with irregular consumption of breakfast. 	✓	-	-	-	-	65%
Al-Muhaimeed (2015)	Cross-sectional	601, 6-10 years, Both	WHO 2000	<ul style="list-style-type: none"> • Eating patterns • TV watching/day • Walk daily • Engage in sports • SES 	<ul style="list-style-type: none"> • Compared to kids who did not eat out at restaurants, those who did were twice as likely to be overweight if they ate there at least twice a week. • Participating in sports for > 2 hours each day reduced the risk of childhood obesity by half compared to those who did not. 	✓	✓	-	-	-	85%
Al-Agha (2016)	Cross-sectional	541, 2-18 years, both	CDC	<ul style="list-style-type: none"> • TV viewing/day • eating during TV viewing • Duration of using electronic devices 	<ul style="list-style-type: none"> • Obesity is positively associated with the history of eating in front of the TV. 	✓	-	-	-	-	55%

				<ul style="list-style-type: none"> • Exercise duration 	<ul style="list-style-type: none"> • Weak negative association between exercise duration and BMI categories. • More than two hours per day spent on digital devices was strongly correlated with BMI. 						
Humeda S. (2016)	Cross-sectional	299, 10-15 years, both	WHO-NCHS	<ul style="list-style-type: none"> • PA 	<ul style="list-style-type: none"> • PA negatively associated with obesity only among boys. 	✓	-	-	-	-	55%
Ali (2016)	Cross-sectional	399, 12-15 years, Male	CDC	<ul style="list-style-type: none"> • TV viewing • Eating during TV viewing • Sleep duration • Type of sport • Eating patterns • Smoking (active) • SES 	Children with fathers who have a college education are more likely to develop obesity than children whose fathers have other types of education. Type of sport (football) was significantly associated with BMI.	✓	✓	✓			65%
Al-Agha (2017)	Cross-sectional	384, 3-18 years, both	WHO 2007	<ul style="list-style-type: none"> • SES 	BMI increases with income families.	-	✓	-	-	-	60%
Al-Kutbe (2017)	Cross-sectional	266, 8-11 years, females	CDC	<ul style="list-style-type: none"> • Energy intake • PA 	<ul style="list-style-type: none"> • Positive association between obesity and energy intake • Negative association between obesity and PA 	✓	-	-	-	-	90%
Alshammari (2017)	Cross-sectional	1420, 2-18 years, both	WHO 2007	<ul style="list-style-type: none"> • SES 	No associations found	-	✓	-	-	-	80%
Alqarni (2017)	Cross-sectional	328, 2-18 years, both	CDC	<ul style="list-style-type: none"> • PA • TV watching • Junk food • SES 	<ul style="list-style-type: none"> • Children with employed fathers and non-employed mothers are more likely to develop obesity. • Children with obesity and overweight belong to the middle family income level, negative association. 	✓	✓	-	-	-	70%

					<ul style="list-style-type: none"> • Weak negative association was found between PA and BMI. • A significant positive correlation between time spent viewing television and BMI. • A significant positive association between BMI and junk food consumption. 						
Alsubaie (2017)	Cross-sectional	725, 7-12 years, N/A	N/A	<ul style="list-style-type: none"> • Sweets and soft drinks consumption /day • Energy drinks consumption /day 	<ul style="list-style-type: none"> • Consuming sweets negatively associated with BMI. 	✓	-	-	-	-	65%
Al-Qahtani (2018)	Cross-sectional	201, 9-14 years, males	CDC	<ul style="list-style-type: none"> • TV watching • Time spent on PC/Video games • Outdoor activity • Soft and energy drinks 	<ul style="list-style-type: none"> • Lack of PA negatively associated with BMI. • Consumption of soft and energy drinks positively associated with BMI. 	✓	-	-	-	-	65%
Alturki (2018)	Cross-sectional	1023, 9-12 years, both	CDC	<ul style="list-style-type: none"> • Consumption of fast food 	<ul style="list-style-type: none"> • Weekly fast-food consumption was positively associated with a higher chance of developing obesity. • Fast food portion sizes were significantly related to an increased likelihood of becoming obese. • Boys were more likely to become obese if they chose a greater piece of French fries. • For boys, the likelihood of being overweight or obese was shown to rise in correlation with the size of the soft drink chosen. 	✓	-	-	-	-	90%

Alturki (2018)	Cross-sectional	1023, 9-12 years, both	CDC	<ul style="list-style-type: none"> • Dietary habits • Sociodemographic factors 	<ul style="list-style-type: none"> • Education level of fathers negatively associated with reduced risk of obesity in boys • No consanguinity between parents associated with reduced risk of obesity in boys • No space at home for PA was positively associated with an increased risk of developing obesity. • Childhood obesity was more prevalent in children from low- and middle-income families than in affluent households. • Obesity in boys was positively associated with eating during ST and frequent eating out. • Home availability of non-core foods and soft drinks and where breakfast is eaten (home) was significantly associated with the risk of being obese. 	✓	✓	✓	-	-	80%
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Abbreviations: PA = Physical activity; TV= television; SES= socio-economic status; PC= personal computer; WHO 2000= the World Health Organization 2000 growth chart; CDC= The Centers for Disease Control and Prevention 2000 growth charts; WHO-NCHS= the National Center for Health Statistics/World Health Organization reference; WHO 2007= the World Health Organization 2007 growth chart; IOTF= International Obesity Task Force growth chart.

Appendix 3: Quality assessment of the included studies

Studies	Axis Items																				Axis Score
	Clear aims	Appropriate study design	Justified sample size	Population defined	Sample representative	Unbiased selection process	measures undertaken to address and categorise non-responders	Variables measured appropriate to the aims of the study	Appropriate measurement tools	Clear statistical significance criteria	Repeatable methods	Basic data adequately described	non-response bias	information about non-responders described	results internally consistent	All results described	Conclusions justified by results	Limitations discussed	Funding sources/ conflicts affecting interpretation	Ethical approval and consent obtained	
Humeda (2016)	√	√	Δ	√	Δ	×	Δ	√	Δ	√	√	√	Δ	×	√	√	√	×	×	Δ	55%
Al-Agha (2016)	√	√	Δ	√	Δ	×	Δ	√	Δ	√	√	√	Δ	×	√	√	×	√	×	Δ	55%
Al-Agha (2017)	√	√	Δ	√	Δ	Δ	Δ	√	Δ	√	√	√	Δ	×	√	√	√	√	Δ	√	60%
AlAlwan (2013)	√	√	Δ	√	√	√	Δ	√	Δ	√	√	√	Δ	×	√	√	√	√	×	√	75%
Al-Enazy (2014a)	√	√	√	√	√	√	Δ	√	Δ	√	√	√	×	×	√	√	√	√	×	√	85%
Al-Ghamdi (2013)	√	√	√	√	√	√	Δ	√	Δ	√	√	√	Δ	Δ	√	√	√	√	×	√	80%
Al-Hazaa (2007a)	√	√	√	√	√	Δ	Δ	√	√	√	√	√	Δ	Δ	√	√	√	√	Δ	√	75%
Al-Hazaa (2007)	√	√	√	√	√	√	Δ	√	√	√	√	√	×	Δ	√	√	√	×	Δ	√	80%
Al-Kutbe (2017)	√	√	√	√	√	N	√	√	Δ	√	√	√	×	√	√	√	√	√	×	√	90%
AlMuammar (2014)	√	√	Δ	√	√	√	Δ	√	Δ	√	√	√	Δ	×	√	√	√	×	Δ	Δ	60%
AlMuhaimeed (2015)	√	√	√	√	√	√	Δ	√	Δ	√	√	√	×	×	√	√	√	√	×	√	85%
Al-Qahtani (2013)	√	√	Δ	√	√	√	Δ	√	Δ	√	√	×	Δ	×	√	√	√	×	×	Δ	60%
Al-Qahtani (2018)	√	√	Δ	√	√	√	Δ	√	Δ	√	√	√	Δ	×	√	√	√	√	Δ	Δ	65%
Al-Saeed (2007)	√	√	Δ	√	√	√	Δ	√	Δ	√	√	√	Δ	×	√	√	√	×	×	√	70%
Al-Shehri (2014)	√	√	√	√	√	Δ	Δ	√	Δ	√	√	√	Δ	×	√	√	√	√	×	√	75%
Alam (2008)	√	√	√	√	√	Δ	Δ	√	Δ	√	√	√	×	×	√	√	√	×	Δ	√	70%

Alenazi (2014)	√	√	Δ	√	√	Δ	Δ	√	Δ	√	√	√	Δ	×	√	√	√	×	×	√	65%
Ali (2016)	√	√	√	√	√	Δ	Δ	√	Δ	√	√	√	Δ	×	√	√	√	×	Δ	√	65%
Alqarni (2017)	√	√	Δ	√	√	√	Δ	√	Δ	√	√	√	Δ	×	√	√	√	×	×	√	70%
Alshammari (2017)	√	√	Δ	√	√	√	Δ	√	√	√	√	√	×	×	√	√	√	√	×	Δ	80%
Alsubaie (2017)	√	√	Δ	√	√	√	Δ	√	Δ	√	√	Δ	Δ	×	√	√	√	√	×	√	65%
Alturki (2018)	√	√	√	√	√	×	Δ	√	√	√	√	√	×	×	√	√	√	√	×	√	90%
Alturki(2018a)	√	√	√	√	√	×	Δ	√	√	√	√	√	×	×	√	√	√	×	×	√	80%
Amin (2008)	√	√	√	√	√	√	Δ	√	√	√	√	√	×	×	√	√	√	×	Δ	√	80%
Khalid (2008)	√	√	√	√	√	×	Δ	√	Δ	√	√	√	×	×	√	√	√	×	Δ	√	70%

Notes: (√= Yes), (Δ= Cannot tell), (×= No).

Appendix 4: A list of search terms

Whole system* approach
System*-based approach
System* science
System* dynamics
System* approach
System* interventions
Dynamic simulation model*
System* thinking
Dynamic behavi*
System* modelling
Agent-based model*
Group model building
Social network analysis
Nonlinear dynamics
Computer simulation
Systems analysis
Overweight
Bodyweight
Obesity
Weight gain
Paediatric obesity
Adiposity
Body mass index

Appendix 5: Included programmes/studies in the scoping review

Study title and years	Country	Target Population	Programme/Intervention characteristics ^a	Evaluation approach	Outcomes	Systems method and Theoretical basis	Findings/comments; results published?	Comprehensiveness as defined in this review
WHO STOPS Childhood Obesity 2016-2021	Australia	Children (grade 2, 4, 6; ages 7-12 years)	-Assessing alignment of the current system with values and assumptions of the targeted outcome. - Exploring the interactions and interdependencies among system subsystems or components -Using the established systems map to identify intervention opportunities and convert these to community-built and systems-oriented action plans.	A stepped-wedged cluster randomised controlled trial	<ul style="list-style-type: none"> Anthropometry (BMIz^b, overweight/obesity prevalence) Social networks Environments QoL PA and Sedentary Diet frequency, type Process/implementation indicators 	Group Model Building (GMB), Systems dynamic	Results Published: YES. Main Result: <i>WHOSTOP</i> positively impacted intake of takeaway food and health-related QoL.	A SAP was used in all stages of the intervention (design, implementation and monitoring)
RESPOND 2018 - 2023	Australia	Birth to 12 years	Five components: 1. Systems approach capacity building for each participating community, including online support and face-to-face GMB training to develop local interventions. 2. School monitoring system. Community-led intervention activity. 3. Collective impact 4. Social network analysis, engagement and knowledge. 5. Community-led intervention.	A stepped-wedged cluster randomised controlled trial	<ul style="list-style-type: none"> BMIz^b Overweight/obesity prevalence average daily intakes of non-essential (discretionary) foods 	Group Model Building (GMB), Systems dynamic	No results published	A systems approach was used in all stages of the intervention (design, implementation and monitoring)
The LIKE 2018-2022	Netherlands	10-14 years	-Understanding the pre-existing systems such as sleep and screen time. -Summarising findings in a systems map and using Social Network Analysis to find actors (societal stakeholders/policymakers) to develop actions using GMB workshops. - Use the understanding gleaned in the systems maps to support	Developmental systems evaluation, supplemented with routinely collected data	<ul style="list-style-type: none"> BMIz^b Behavioural (diet, physical activity, screen use and sleep) 	Group Model Building (GMB), social network analysis (SNA), Systems dynamic	No results published	A systems approach was used in all stages of the intervention (design, implementation and monitoring)

		adaptation, continuous, and feedback on changes as the intervention programme was implemented.					
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^a: Unlike traditional intervention studies where intervention components are clearly defined, and adherent to protocol, the interventions implemented or delivered in the three included studies involved GMB and capacity-building work in participating communities. The intervention actions varied between communities and evolved (were modified) in response to ongoing evaluation results. This is an important sign of the authentic use of SAP.

^b: Body Mass Index z score (standard deviation score)

Appendix 6: Excluded studies/programmes and reasons for exclusion

First author and year	Year	DOI/Link	Reason for exclusion
Whelan, j.	2019	https://doi.org/10.1186/s12889-019-7644-x	It did not provide details on how the programme developed.
Webber	2014	https://doi.org/10.21101/cejph.a3877	Theoretical or commentary papers
Waterlander	2020	https://doi.org/10.1111/obr.13185	Only testing a tool of systems thinking
Wang, y.	2015	https://doi.org/10.3945/an.114.007203	Theoretical or commentary papers
Wang, y. F.	2014	https://doi.org/10.3945/an.114.006650	Theoretical or commentary papers
Waterlander, w.	2018	https://doi.org/10.1016/j.agsy.2017.01.006	Theoretical or commentary papers
Waqqa	2017	https://doi.org/10.1186/s12961-017-0240-6	Only testing a tool of systems thinking
Waqqa	2017	https://doi.org/10.1186/s12889-016-3944-6	Only testing a tool of systems thinking
Abidin	2014	https://doi.org/10.1371/journal.pone.0114135	Only testing a tool of systems thinking
Abidin	2014	https://doi.org/10.1371/journal.pone.0114135	Theoretical or commentary papers
Wang	2014	https://doi.org/10.1186/1471-2458-14-923	Only testing a tool of systems thinking
Abidin	2016	https://doi.org/10.1111/jt.v78.9009	Theoretical or commentary papers
Abidin	2017	https://doi.org/10.1063/1.5012189	Theoretical or commentary papers
Abidin	2015	https://doi.org/10.1186/s12889-019-6501-2	Only testing a tool of systems thinking
Wall	2017	PMID: 29727077	Theoretical or commentary papers
Van Woudenberg	2019	https://doi.org/10.2196/12914	Only testing a tool of systems thinking
Wachhaus	2020	https://doi.org/10.1177/0275074019864298	Only testing a tool of systems thinking
Vanmil	2014	https://doi.org/10.1016/j.tifs.2014.07.005	Theoretical or commentary papers
Vamos	2016	https://doi.org/10.1186/s12889-020-09694-2	It did not use any systems thinking tools and did not bound the system; interventions were not based on interactions of interrelated factors.
Tissier	2018	https://doi.org/10.1371/journal.pone.0192853	Theoretical or commentary papers
Breeze	2017	https://doi.org/10.1111/dme.13349	Outcomes
Bowen	2015	https://doi.org/10.1146/annurev-publhealth-032013-182516	Review papers
Black	2013	https://doi.org/10.1093/jpepsy/jst071	Theoretical or commentary papers
Skouteris	2015	https://doi.org/10.1111/ajo.12341	Theoretical or commentary papers
Sonntag	2018	https://doi.org/10.1111/obr.12683	Theoretical or commentary papers
Teeters	2018	https://doi.org/10.1186/s12961-017-0262-0	Assessing the readiness before developing a systems interventions
Siokou	2014	https://doi.org/10.17061/phrp2511404	Theoretical or commentary papers
Simone	2018	https://doi.org/10.1007/s10964-017-0796-z	Only testing a tool of systems thinking
David A	2009	N/A, Title "Social network analysis of adolescent obesity"	Theoretical or commentary papers

Bolton	2017	https://doi.org/10.1038/ijo.2017.73	Used multi-components interventions and did not bound the system or use mental models
Silverman	2018	https://doi.org/10.1162/artl_a_00264	Theoretical or commentary papers
Springer	2017	https://doi.org/10.3389/fpubh.2017.00268	Theoretical or commentary papers
Tanenbaum	2017	N/A, Title "Development and validation of an agent-based model to examine neuroticism and obesity"	Only testing a tool of systems thinking
Southerland	2015	https://doi.org/10.14423/smj.0000000000000238	School-based (not a population level)
Shoham	2010	N/A, Title "Agent-based model of peer influence on obesity"	Only testing a tool of systems thinking
Bensberg	2020	https://doi.org/10.1002/hpja.325	Outcomes
Bensberg	2021	https://doi.org/10.1177/1524839919897266	Outcomes
Andersonsteeves	2014	https://doi.org/10.1007/s13679-014-0120-0	Theoretical or commentary papers
Auchincloss	2011	https://doi.org/10.1016/j.amepre.2010.10.033	Only testing a tool of systems thinking
Brittin	2015	https://doi.org/10.1057/jos.2014.16	Only testing a tool of systems thinking
Brimblecombe	2015	https://doi.org/10.1016/j.healthplace.2015.03.006	Developed a tool structure and implementation approach to enable community engagement
Brock	2019	https://doi.org/10.1097/fch.0000000000000212	Describing capacity building experiences, process and barriers and facilitators related to partnership and sustainability through the use of community based participatory research
Cammock	2020	https://doi.org/10.1016/j.healthpol.2020.12.001	Theoretical or commentary papers
Brennan	2015	https://doi.org/10.1097/phh.0000000000000248	Using group model building as a part of an evaluation process
Allender	2015	https://doi.org/10.1371/journal.pone.0129683	Only testing a tool of systems thinking
Allender	2019	https://doi.org/10.1111/obr.12865	Theoretical or commentary papers
Amed	2016	https://doi.org/10.3390/ijerph13060614	Describing how to facilitate and sustain the beginnings of a systems-level/community-level change
Widener	2013	https://doi.org/10.1136/bmjopen-2017-019376	Theoretical or commentary papers
Wright	2019	https://doi.org/10.12688/wellcomeopenres.15443.1	Developed their logic model without using systems science tools or bounding the system.
Aziza	2019	https://doi.org/10.1016/j.jbi.2019.103101	Theoretical or commentary papers
Burke	2020	https://doi.org/10.1177/1090198119876239	Theoretical or commentary papers
Bures	2014	https://doi.org/10.2105/ajph.2014.302082	Theoretical or commentary papers
Calancie	2020	https://doi.org/10.1097/phh.0000000000001213	Only testing a tool of systems thinking
Zhang	2018	https://doi.org/10.1111/obr.12684	Review papers
Serpas	2013	https://doi.org/10.1353/hpu.2013.0107	did not bound the system, did not use mental models
Schauder	2020	https://doi.org/10.1016/j.pmedr.2020.101173	Only testing a tool of systems thinking

Seifu	2018	https://doi.org/10.1057/s41271-018-0125-0	Outcomes
Sanchez-Romero	2016	https://doi.org/10.1371/journal.pmed.1002158	Only testing a tool of systems thinking
Wang	2014	https://doi.org/10.1007/s10198-013-0472-5	Outcomes
Shi	2020	https://doi.org/10.1371/journal.pone.0236716	Only testing a tool of systems thinking
Schaefer	2014	https://doi.org/10.2105/ajph.2013.301768	Only testing a tool of systems thinking
Savona	2019	https://doi.org/10.1016/S0140-6736(19)32880-6	Only testing a tool of systems thinking
Zhang	2015	https://doi.org/10.2105/ajph.2014.302277	Only testing a tool of systems thinking
Yang	2017	https://doi.org/10.1111/nyas.13558	Only testing a tool of systems thinking
Bales	2008	PMID: 18999104	Theoretical or commentary papers
Beleigoli	2018	https://doi.org/10.3233/978-1-61499-914-0-1	Review papers
Thomas	2015	https://doi.org/10.1097/phh.0000000000000209	Only testing a tool of systems thinking
Sautkina	2014	https://doi.org/10.1016/j.healthplace.2014.05.006	Outcomes
Belay	2019	https://doi.org/10.3233/hab-190376	Only testing a tool of systems thinking
Bagnall	2019	https://doi.org/10.1186/s12889-018-6274-z	Review papers
Beheshti	2017	https://doi.org/10.1016/j.ssmph.2017.01.006	Only testing a tool of systems thinking
Xue	2018	https://doi.org/10.1111/obr.12695	Review papers
Zhang	2015	https://doi.org/10.1016/j.socscimed.2014.05.049	Only testing a tool of systems thinking
Xue	2017	N/A, Title” Agent-based modeling of social norm impacts on obesity and eating behaviors among school children in China and the United States”	Only testing a tool of systems thinking
Shin	2014	https://doi.org/10.1002/oby.20731	Only testing a tool of systems thinking
Riley, t	2021	https://doi.org/10.1007/s11213-020-09544-7	Theoretical or commentary papers
Raffa	2017	https://doi.org/10.1007/s11606-016-3948-z	Theoretical or commentary papers
Prochnow	2020	https://doi.org/10.1123/jpah.2019-0655	Only testing a tool of systems thinking
Prochnow	2020	https://doi.org/10.1123/jpah.2019-0350	Review papers
Petticrew	2017	https://doi.org/10.1136/jech-2017-209710	Theoretical or commentary papers
Orr	2016	https://doi.org/10.1136/jech-2015-205621	Only testing a tool of systems thinking
Oreskovic	2015	https://doi.org/10.2196/mhealth.4150	Theoretical or commentary papers
Persky	2011	https://doi.org/10.1177/193229681100500220	Theoretical or commentary papers
Parkinson	2017	https://doi.org/10.1108/JSOCM-03-2017-0021	Theoretical or commentary papers
Roesler	2020	https://doi.org/10.1177/0260106020917290	Only testing a tool of systems thinking
Roberts	2019	https://doi.org/10.1002/sres.2555	Only testing a tool of systems thinking
Pronk	2016	https://doi.org/10.1097/jom.0000000000000648	Theoretical or commentary papers
Powell	2017	https://doi.org/10.1177/0033354917723601	Theoretical or commentary papers
Bellew	2020	https://doi.org/10.1123/jpah.2019-0121	Using PA systems maps for advancing systems approach applications
Salgado	2020	https://doi.org/10.1371/journal.pmed.1003224	Outcomes

Roussy	2020	https://doi.org/10.1093/heapro/daz065	Theoretical or commentary papers
Palmer	2007	https://doi.org/10.1185/030079907x182194	Outcomes
Owen	2018	https://doi.org/10.1371/journal.pone.0195141	Only testing a tool of systems thinking
Salihu	2015	https://doi.org/10.4081/jphr.2015.443	Only testing a tool of systems thinking
Sandu	2015	https://doi.org/10.1186/s12961-016-0168-2	Conference papers
Salsberg	2015	https://doi.org/10.47197/retos.v0i28.34961	Did not use mental models and school-based (not a population level)
Holdsworth	2017	https://doi.org/10.1186/s12966-017-0608-6	Only testing a tool of systems thinking
Hoehner	2015	https://doi.org/10.1097/phh.0000000000000211	Only testing a tool of systems thinking
Kleven	2018	https://doi.org/10.1542/peds.141.1MA6.583	Theoretical or commentary papers
Keane	2015	https://doi.org/10.1097/phh.0000000000000250	Only testing a tool of systems thinking
Kasman	2019	https://doi.org/10.1002/oby.22553	Only testing a tool of systems thinking
Njeru	2020	https://doi.org/10.1186/s12889-020-8315-7	Only testing a tool of systems thinking
Nianogo	2015	https://doi.org/10.2105/ajph.2014.302426	Review papers
Mcglashan	2019	https://doi.org/10.1038/s41598-019-47759-4	Only testing a tool of systems thinking
Luke	2012	https://doi.org/10.1146/annurev-publhealth-031210-101222	Review papers
Chen	2019	https://doi.org/10.1371/journal.pmed.1002975	Review papers
Chung	2019	https://doi.org/10.1111/jnu.12453	Only testing a tool of systems thinking
Clarke	2018	https://doi.org/10.3390/ijerph15112393	Only testing a tool of systems thinking
Cauchi	2016	https://doi.org/10.1111/obr.12441	Review papers
Cavill	2020	https://doi.org/10.4081/jphr.2020.1759	Only testing a tool of systems thinking
Carey	2015	https://doi.org/10.1136/bmjopen-2015-009002	Review papers
Huang	2013	https://doi.org/10.1089/chi.2013.9102	Theoretical or commentary papers
Holley	2019	https://doi.org/10.1007/s13668-019-0258-1	Review papers
Koh	2019	https://doi.org/10.1007/s12571-019-00900-7	Only testing a tool of systems thinking
Hennessy	2016	https://doi.org/10.5888/pcd13.150414	Only testing a tool of systems thinking
Kapoor	2020	PMID: 32794511	Theoretical or commentary papers
Johnston	2014	https://doi.org/10.2105/ajph.2014.301884	Review papers
Langellier	2019	https://doi.org/10.1016/j.amepre.2019.03.017	Review papers
Lan	2014	https://doi.org/10.1155/2014/575424	Only testing a tool of systems thinking
Lee	2018	https://doi.org/10.1016/j.amepre.2017.11.003	Only testing a tool of systems thinking
Lee	2017	https://doi.org/10.1093/nutrit/nuw049	Theoretical or commentary papers
Malakellis	2017	https://doi.org/10.1111/1753-6405.12696	School-based (not a population level), did not use mental models
Mabry	2014	https://doi.org/10.2105/ajph.2014.302083	Theoretical or commentary papers
Madahian	2011	https://doi.org/10.1186%2F1471-2105-13-S12-A13	Only testing a tool of systems thinking

Lloyd	2011	https://doi.org/10.1186/1479-5868-8-73	School-based (not a population level), did not use mental models
Li	2014	https://doi.org/10.1109/WSC.2014.7019979	Only testing a tool of systems thinking
Li	2016	https://doi.org/10.5888/pcd13.150561	Review papers
Li	2018	https://doi.org/10.3390/su10051575	Only testing a tool of systems thinking
Levy	2011	https://doi.org/10.1111/j.1467-789x.2010.00804.x	Review papers
Li	2019	https://doi.org/10.1016/j.socscimed.2019.05.026	Only testing a tool of systems thinking
Korn	2017	N/A, Title “Use of group model building to develop implementation strategies for early childhood obesity prevention”	Only testing a tool of systems thinking
Mcglashan	2018	https://doi.org/10.1002/osp4.306	Theoretical or commentary papers
Meisel	2020	https://doi.org/10.1136/bmjopen-2019-036534	Only testing a tool of systems thinking
Mcglashan	2018	https://doi.org/10.1371/journal.pone.0196211	Only testing a tool of systems thinking
Matheson	2018	https://doi.org/10.1093/pubmed/idx117	Theoretical or commentary papers
Marks	2018	https://doi.org/10.1093/tbm/iby026	Only testing a tool of systems thinking
Mainor	2014	https://doi.org/10.1097/phh.0000000000000046	Theoretical or commentary papers
Low	2016	https://doi.org/10.1016/j.socscimed.2016.04.011	Only testing a tool of systems thinking
Liu	2016	https://doi.org/10.1057/jors.2015.99	Only testing a tool of systems thinking
Crane	2019	https://doi.org/10.1002/hpja.239	Theoretical or commentary papers
Clarke	2020	https://doi.org/10.1016/j.socscimed.2019.112757	Theoretical or commentary papers
Nobles	2019	https://doi.org/10.1016/j.healthpol.2019.07.016	Theoretical or commentary papers
Meisel	2016	https://doi.org/10.1108/K-01-2015-0010	Only testing a tool of systems thinking
Manios	2012	https://doi.org/10.1111/j.1467-789x.2011.00974.x	School-based (not a population level), did not use mental models
Marks	2013	https://doi.org/10.1155/2013/919287	Only testing a tool of systems thinking
Liu	2018	https://doi.org/10.1002/sres.2460	Review papers
Dobson	2019	https://doi.org/10.1098/rstb.2018.0053	Theoretical or commentary papers
Cockrellskinner	2013	https://doi.org/10.1155/2013/129193	Review papers
Chen	2017	https://doi.org/10.1111/ijpo.12126	Only testing a tool of systems thinking
Haynes	2020	https://doi.org/10.1186/s12961-020-00600-1	Theoretical or commentary papers
Gortmaker	2011	https://doi.org/10.1016/s0140-6736(11)60815-5	Theoretical or commentary papers
Gittelsohn	2015	https://doi.org/10.1007/s13679-015-0147-x	Theoretical or commentary papers
Gadsby	2020	https://doi.org/10.1186/s12889-020-09694-2	It did not bound the system and did not use mental models.
Gandjour	2012	https://doi.org/10.1586/erp.12.13	Theoretical or commentary papers
Giabbanelli	2017	https://doi.org/10.1155/2017/5742629	Theoretical or commentary papers
Friel	2017	https://doi.org/10.1371/journal.pone.0188872	Theoretical or commentary papers
Guariguata	2020	https://doi.org/10.3390/nu12020384	Only testing a tool of systems thinking
Grummon	2019	https://doi.org/10.1016/j.amepre.2019.06.022	Only testing a tool of systems thinking

Gortmaker	2012	https://doi.org/10.1016/s0140-6736(11)60815-5	Theoretical or commentary papers
Hayward	2020	https://doi.org/10.1038/s41746-020-0230-x	Only testing a tool of systems thinking
Hayre	2020	https://doi.org/10.1136/archdischild-2020-320552	Theoretical or commentary papers
Mui	2019	https://doi.org/10.1371/journal.pone.0216985	Outcomes
Hammond	2012	https://doi.org/10.1073/pnas.0913003109	Theoretical or commentary papers
Naimi	2016	https://doi.org/10.1097/ede.0000000000000538	Theoretical or commentary papers
Mosavel	2018	https://doi.org/10.1353/cpr.2018.0042	Only testing a tool of systems thinking
Frerichs	2018	https://doi.org/10.1177/1090198117726570	Only testing a tool of systems thinking
Brownson	2015	https://doi.org/10.1097/phh.0000000000000233	The approach was not applied beyond the intervention development stage
Sallis	2015	https://doi.org/10.1097/phh.0000000000000246	The approach was not applied beyond the intervention development stage
Gittelsohn	2014	https://doi.org/10.1186/1471-2458-14-942	The approach was not applied beyond the intervention development stage
El-sayed	2012	N/A, Title” Intervening to reduce obesity: an agent-based modeling approach to assess the efficacy of network-based interventions”	Only testing a tool of systems thinking
Economos	2012	https://doi.org/10.1089/chi.2011.0121	Theoretical or commentary papers
D'souza	2017	N/A, Title “Systems mapping of unhealthy food environments in Auckland schools: a case study”	Only testing a tool of systems thinking
Nelson	2015	https://doi.org/10.1097/phh.0000000000000219	Only testing a tool of systems thinking
Finegood	2012	https://doi.org/10.1159/000341308	Theoretical or commentary papers
Fallah-fini	2019	https://doi.org/10.1002/oby.22497	Only testing a tool of systems thinking
Morshed	2019	https://doi.org/10.1111/obr.12877	Review papers
Gittner	2017	https://doi.org/10.1016/j.orcp.2017.05.001	Only testing a tool of systems thinking
Nam	2019	N/A, Title “Social network analysis of obesity-related behaviors in African American church-based friendships”	Only testing a tool of systems thinking
Frerichs	2018	https://doi.org/10.1016/j.evalprogplan.2018.03.003	Only testing a tool of systems thinking
Frerichs	2019	https://doi.org/10.1016/j.healthplace.2019.04.001	Review papers
Jancey	2019	https://doi.org/10.1136/bmjopen-2018-027948	Trial protocols
Jayasinghe		https://doi.org/10.1186/s12939-015-0205-8	Theoretical or commentary papers
Hamilton	2019	N/A, Title” Addressing obesity in Stevenage, Hertfordshire: a consultation with young people”	Did not use a mental model
Copeland	2020	N/A, Title “Sheffield-let's change4life: a whole systems approach to tackling overweight and obesity in children, young people and families-a local evaluation report	Evaluation report for local efforts

Nam	2019	https://doi.org/10.1177/1090198118778323	Not reporting behavioural or anthropometric outcomes
Maitland	2019	https://doi.org/10.1186/s12889-019-7936-1	Trial protocols

Appendix 7: Quality assessment of included programmes/studies

A) The quality assessment of the included SW-CRT (using The Consolidated Standards of Reporting Trials (CONSORT) extension abstracts)

Items		Required Information to Meet Criteria	Reviewer's Judge
Title		Identification of the study as stepped wedge trial	Yes
Authors		Contact details for the corresponding author	Yes
Trial design		Description of the trial design (e.g., parallel, cluster, non-inferiority, stepped wedge)	Yes
Methods	Participants	Eligibility criteria for participants/clusters and the settings where the data were collected	Yes
	Interventions	Interventions intended for each group (cluster)	Yes
	Objective	Specific objective or hypothesis	Yes
	Outcome	Clearly defined primary outcome for this report	Yes
	Randomisation	How participants/clusters were allocated to interventions	No
	Blinding	Whether or not participants, caregivers, and those assessing the outcomes were blinded to group assignment	NA
Results	Numbers randomised	Number of clusters (number of participants) randomised to each group;	Yes
	Recruitment	Trial status	No
	Number analysed	Number of participants analysed in each group (cluster)	Yes
	Outcome	For the primary outcome, a result for each group (cluster) and the estimated effect size and its precision	Yes
	Harms	Important adverse events or side effects	Yes
	Conclusions	General interpretation of the results	Yes
Trial registration		Registration number and name of trial register	Yes
Funding		Source of funding	No

B) The quality assessment of the included process evaluation (using the standard Critical Appraisal Skills Programme and EPPI-Centre tool)

Study details		Characteristics of process evaluation
Stated aim of study	To examine the SEA Change Portland process to identify significant events, enablers and barriers of its development and implementation to date	
Methods	Data collection: Semi-structured interviews Data analysis: Data were analysed under three key themes: collective impact, systems thinking, and asset-based community development (ABCD)	
Details of participants	Eight steering group members and three community task team members.	
Details of the programme	Description: community-led obesity prevention initiative Target population: children aged 7–12 years Theory: a systems-based approach Setting: The regional seaside town of Portland Length/intensity: 12 months	
Quality appraisal		
Questions	Reviewer judgment	Description
Were steps taken to minimise bias and error/increase rigour in sampling?	Cannot tell	Limited description of sampling method
Were steps taken to minimise bias and error/increase rigour in data collection?	Yes	Semi-structured, participants given the opportunity to ask questions and open-ended questions used, follow-up questions
Were steps taken to minimise bias and error/increase rigour in data analysis?	Cannot tell	Thematic analysis conducted by one Interviewer, Insufficient detail to judge
Were the findings of the study grounded in/supported by data?	Yes	The data presented illuminate/illustrate the findings
There was good breadth and/or depth achieved in the findings?	Yes	Good breadth and depth
The perspectives of interviewees were privileged?	Yes	Their 'voice' is clearly represented in the data.
Overall reliability and usefulness of findings		
Reliability of findings	High	
Usefulness of findings	High	

Appendix 8: The recruitment email



Dear (authority director name or individual name),

My name is Mohammed Alharbi, a Doctoral researcher funded by Ministry of Education in Saudi Arabia to work with Dr Bai Li and Dr Charlie Foster at the University of Bristol for a leading public health challenge that is facing Saudi Arabia.

We are undertaking an important and novel research project that aims to explore the feasibility of applying a systems approach for developing childhood obesity prevention interventions in Makkah city, Saudi Arabia. This will be the first study of its kind not only in our country but in the region, and so is likely to have significant impacts.

Obesity has massive costs on individuals and the societies. The global annual estimated cost of obesity is about US \$2 trillion, nearly 2.8% of global gross domestic product. However, current approaches (e.g., educational programmes focusing on changing the individuals) to interventions have failed to halt the rise of obesity and related non communicable diseases. To effectively tackle this leading, global public health crisis, leading international experts in obesity research are calling for the use of a systems approach and have demonstrated the value of this new approach in western countries such as Australia and the UK. Importantly, no research studies have applied systems thinking to develop obesity interventions in low- and middle-income countries. Therefore, I am very excited to present this great opportunity for Makkah city to lead the way of testing and demonstrating this new approach's application in a new cultural setting to advance its methodological development and maximise its global impacts.

In this research project, we will explore factors that may influence a government's ability to implement a systems approach to childhood obesity prevention in the Saudi community. Findings of this research will help to maximise the feasibility to apply this new approach to combating childhood obesity in Saudi Arabia and provide helpful lessons for other countries that share similar socio-economic/cultural conditions.

The research has received ethical approval from the University of Bristol's School for Policy Studies Research Ethics Committee (available on request).

As you are a valued member of Makkah community or your organisation is an important body to our research, I am writing to invite you/your organisation to participate in this research. If you are a local authority director and happy to give your permission, you or a few members of your organisation will be invited to take part. Upon the receipt of your expression of interest, you or a nominated member of your organisation will be invited to contribute to a project component that is most relevant to your knowledge and experience (these are likely to be online interviews or workshops). All data will be collected virtually.

This research may benefit you/your organisation as you will experience a new way of thinking and working to potentially solve a major public health crisis in your community. If you have any questions or are interested in being part of this important study, please replay to the researcher and/or contact him on the details provided below.

Kind regards,

Mohammed Alharbi,
Centre for Exercise, Nutrition and Health Sciences,
University of Bristol, BS8 1TZ, UK,
E: gk19069@bristol.ac.uk
P: UK: +447366101923, KSA: +966555056670

Appendix 9: Participant's Information Sheet (Community Readiness Model)

Study title: Assessing community readiness for childhood obesity prevention in Makkah city, Saudi Arabia.

I would like to invite you to take part in a research study. Before you decide whether to take part, you need to understand why the research is being done and what it would involve for you. This study is part of a doctoral research sponsored by the Ministry of Education in Saudi Arabia. Please take time to read the following information carefully. Ask questions if anything you read is not clear or if you would like more information. Take time to decide whether or not to take part.

1- What is the purpose of the study?

- Current approaches to interventions have failed to halt the rise of obesity and related non-communicable diseases.
- Leading international experts in obesity research are calling for the use of a systems approach to obesity prevention.
- Assessing community readiness will assist in determining the feasibility of using a system approach to obesity prevention.
- This study aims mainly to assess how your community is ready to prevent obesity among children aged 2-18 years.

2- Why have I been invited?

- You are receiving this material either because you are working in a local authority/organisation or a valued member of Makkah community.

3- What will happen to me if I decide to take part?

- Once you have agreed to take part and signed the consent form, I will interview you for around 60 minutes. You can choose the date and time of the interview.
- The interview will be audio recorded with your agreement (all identifying information will be anonymised) and written up so that I can evaluate what has been said.
- The interview will be conducted using an online application such as Skype Business or Microsoft Teams.
- You will be able to withdraw from the study at any time without giving a reason and without any effects. You have the right to request that all information held about you is deleted. However, it may be impossible to delete information once data have been analysed.

4- Do I have to take part?

- Participation in our study is entirely voluntary. If you do decide to take part, you will be asked to sign a consent form. You will be able to withdraw from the study at any time without giving a reason and without any effects. You have the right to request that all information held

about you is deleted. However, it may be impossible to delete information once data have been analysed.

5- Are there any possible disadvantages or risks from taking part?

- The interviews will not ask any sensitive questions, so there are no anticipated risks associated with your involvement in this study.

6- What are the possible benefits of taking part?

- Taking part in this research will not benefit you personally. However, the information you provide is critical to highlight future areas for action regarding childhood obesity in your community as well as things that are being done well.

7- Will information be confidential?

- **Yes.** All information collected will be treated confidentially. However, confidentiality will be broken if a risk of serious harm to yourself or others is disclosed.
- All data will be stored using a protected- password on the University server (OneDrive) and will be only accessible by the research team.
- Your data will be anonymised entirely. Any identifying features that might be used in order to identify you will be anonymised or eliminated accordingly.
- Your name, position and organisation/authority will also be anonymised and pseudonymised. A pseudonym name and number will be used throughout my thesis and in any other forms of dissemination.
- To ensure confidentiality, you have to be alone in a private room. The interview will not be conducted if there is no private room.
- The School for Policy Studies Research Ethics committee (SPS REC) at the University of Bristol has approved this research.

8- What will happen to my data?

- Your anonymised transcript will be used in the various outputs (PhD thesis, conferences, publications and presentations).
- The online platform will be used to audio record the interview. The audio recording and transcripts will be stored using a protected password on the University server (One Drive), and the audio recording will be removed from the platform straight after the interview.
- Interview recordings will be transcribed by a native Arabian citizen (myself) in Arabic and only the necessary quotes will be translated into English.
- With your permission, the anonymised transcripts will be deposited/archived in the university's Research Data Repository, data.bris, and it might be used for future research and learning.

- All the data at the end of the study will be stored for 20 years on an appropriate storage facility at the University of Bristol until it is no longer needed when it will be safely shredded or erased.

9- What if there is a problem?

- For any complaints about poor research practice, please contact principal supervisor: Dr Bai Li via Email: bai.li@bristol.ac.uk or P: +44(0)1773310978.

10- Who is organising and funding the study?

- This research is funded by the Ministry of Education in Saudi Arabia and conducted by a doctoral researcher at the University of Bristol.

11- What will happen now?

- If you would like to take part in this study, then please complete the enclosed consent form and return it to the researcher by email.
- Once I have received your consent form, I will contact you to discuss the date and time of interview.

12- Further information and contact details

Please contact **Mr Mohammed Alharbi; Doctoral Researcher** -the University of Bristol, School for policy studies, Centre for Exercise, Nutrition and Health Sciences. **E-mail:** ek19069@bristol.ac.uk ; **P:** UK: +447366101923, KSA: +96655505667

Appendix 10: Consent form (For Interviews)

Informed Consent for Exploring the Feasibility of Using a Systems Approach to The Development of Childhood Obesity Prevention Interventions in Makkah City, Saudi Arabia

Please tick the appropriate boxes	Yes	No
1. Taking part in the study		
I have read and understood the study information dated [/ /], or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.	<input type="checkbox"/>	<input type="checkbox"/>
I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.	<input type="checkbox"/>	<input type="checkbox"/>
I understand that I have the right to request that all information held about me is deleted.	<input type="checkbox"/>	<input type="checkbox"/>
I understand that taking part in the study involves an audio-recorded interview, which will be transcribed and analysed by Mohammed (the researcher), and the audio recording will be wiped from the online platform straight after the interview.	<input type="checkbox"/>	<input type="checkbox"/>
I agree to the interview being voice recorded.	<input type="checkbox"/>	<input type="checkbox"/>
I understand that the researcher has agreed not to reveal my identity and personal details, including where information about this project is published or presented in any public form.	<input type="checkbox"/>	<input type="checkbox"/>
I understand that there is a low chance that I may be recognised in the outputs. <u>(please tick this only if you are nominated by your senior manager)</u>	<input type="checkbox"/>	<input type="checkbox"/>
I understand that confidentiality will be broken if a risk of serious harm to myself or others is disclosed.	<input type="checkbox"/>	<input type="checkbox"/>
I understand that if I want to see my transcript, the request to view it should be made no earlier than 30 days following the interview. I understand that once data analysis has taken place, I will no longer be able to view my transcript.	<input type="checkbox"/>	<input type="checkbox"/>
2. Use of the information in the study		
I understand that information I provide will be used for a PhD thesis, conferences, publications and presentations.	<input type="checkbox"/>	<input type="checkbox"/>
I understand that personal information collected about me that can identify me, such as my name or where I live/work, will not be shared beyond the study team.	<input type="checkbox"/>	<input type="checkbox"/>
I agree that my information can be anonymously quoted in research outputs.	<input type="checkbox"/>	<input type="checkbox"/>
I understand that access to the (anonymised) interview transcript will be limited to the research team.	<input type="checkbox"/>	<input type="checkbox"/>
3. Future use and reuse of the information by others		
I give permission for the anonymised transcript that are created from my interview to be deposited in the University's Research Data Repository, data.bris so it can be used for future research and learning.	<input type="checkbox"/>	<input type="checkbox"/>
4. Signatures		
Name of participant	Signature	Date
_____	_____	_____
I have accurately read out the information sheet to the potential participant and, to the best of my ability, ensured that the participant understands to what they are freely consenting.		
Name of researcher	Signature	Date
Mohammed Alharbi	_____	_____
5. Study contact details for further information		
Mohammed Alharbi; P: +447366101923; Email: gk19069@bristol.ac.uk		
Lead Supervisor: Dr Bai Li; P: +44(0)1773310978; Email: bai.li@bristol.ac.uk		

Appendix 11: Ethics Approval

School for Policy Studies



8 Priory Road
Bristol BS8 1TZ
Tel: +44 (0)117 954 6755
Fax: +44 (0)117 954 6756
bristol.ac.uk/sps

9 March 2021

Mohammed Alharbi
School for Policy Studies
University of Bristol
8 Priory Road

Dear Mohammed

Project Title: The feasibility of applying a systems approach to developing childhood obesity prevention interventions in Makkah city, Saudi Arabia.

Reference number: SPSREC/20-21/124

The School for Policy Studies Research Ethics Committee has reviewed your application regarding this project, and we have received your responses to our requests for clarification. As such I am happy to provide Research Ethics Committee approval for this project.

Please do not hesitate to contact me if you have any queries.

Yours sincerely

[Redacted signature]

(on behalf of)

Beth Tarleton
Chair of the Policy Studies Research Ethics Committee

Appendix 12: Topic guide of the Community Readiness Model

1) Questions of dimensions A&B: Existing Efforts & Community Knowledge of Efforts

1	On a scale of 1-10, how much of a concern is childhood obesity to Makkah city? 1-not at all, 10= major concern. Are there efforts in Makkah that address specifically obesity for the age group 2-18 years?
2	Please describe each of these efforts?
3	How long has each of these efforts been going on? Probes: Could you please elaborate?
4	Using a scale from 1-10, how aware are people in Makkah of these efforts (none, a few, some, many, or most)? Explain more? Probes: How many community members would you say have heard of efforts? Are they able to name efforts and know their purpose?
5	What does the community know about these efforts or activities? Why do you think members of your community have this amount of knowledge?
6	What are the strengths of these efforts?
7	What are the weaknesses of these efforts?
8	Who does each of these efforts serve? (Individuals of a certain age group, ethnicity, etc.)
9	Would there be any segments of the community for which these efforts/services may appear inaccessible?
10	Is there a need to expand these efforts/services? If not, why not?
11	Is there any planning for efforts/services going on in your community surrounding this issue? If yes, please explain
12	What formal or informal policies, practices and laws related to this issue are in place in your community, and for how long?
13	Are there segments of the community for which these policies, practices and laws may not apply?
14	Is there a need to expand these policies, practices and laws? If so, are there plans to expand them? Please explain.
15	How does the community view these policies, practices and laws?

2) Questions of dimension C: Leadership

16	What are the leaders' roles that are supportive of addressing this issue in your community? Probes: Are there leaders who might oppose addressing obesity? How do they show their opposition?
17	Using a scale from 1-10, how much of a concern is childhood obesity to the leadership of Makkah, with 1 being "not a concern at all" and 10 being "a very major concern"? Can you tell me why you chose that? How much of a priority is addressing this issue to leadership? Can you explain why you say this?
18	How are these leaders involved in efforts regarding childhood obesity? Please explain. (For example: Are they involved in a committee, task force, etc.? How often do they meet?) Can you please tell me whether none, a few, some, many or most leaders would or do show support in this way? (Developing, improving or implementing efforts, allocating resources, ensuring the long-term viability of community efforts)
19	Would the leadership support additional efforts? expanded efforts? If yes: How do, they show this support?

3) Questions of dimension D: Community Climate

20	Describe your community?
21	Are there ever any circumstances in which members of your community might think that this issue should be tolerated. Please explain.
22	How does the community support the efforts to address this issue? (Developing, improving or implementing efforts, willing to pay more)
23	What are the primary obstacles to efforts addressing this issue in your community?
24	Based on the answers that you have provided so far, what do you think is the overall feeling among community members regarding this issue? (Priority of addressing childhood obesity)

4) Questions of dimension E: Knowledge About the Issue

25	On a scale of 1 to 10 where a 1 is no knowledge and a 10 is detailed knowledge How much do community members know about childhood obesity? Prompt: dynamics, signs, symptoms, local statistics, effects on family and friends, etc.) Why?
26	What type of information is available in your community regarding this issue? (Misconceptions, why it occurs)
27	What local data are available on this issue in your community?
28	How do people obtain this information in your community? Brochures, newspapers, media, etc?

5) Dimension F: Resources for Efforts

29	To whom would an individual affected by this issue turn to first for help in your community? Why?
30	On a scale from 1 to 10, what is the level of expertise and training among those working on this issue (with 1 being “very low” and 10 being “very high”)? Please explain
31	Do efforts that address childhood obesity have a broad base of volunteers?
32	What is the community’s and/or local business’ attitude about supporting efforts to address this issue, with people volunteering time, making financial donations, and/or providing space?
33	How are current efforts funded? Is this funding likely to continue into the future? Please explain.
34	Are you aware of any proposals or action plans that have been submitted for funding that address this issue in your community? If yes, please explain.
35	Do you know if there is any evaluation of efforts that are in place to address this issue? If yes, on a scale of 1 to 10, how sophisticated is the evaluation effort (with 1 being “Not at all” and 10 being “very sophisticated?”)?
36	Are the evaluation results being used to make changes in programs, activities, or policies or to start new ones?

Appendix 13: The CRM scores.

SCORER 1

Interviews	One	Two	Three	Four	Five	Six	Seven	Eight
Dimension A	7.5	5.5	4.5	6	6	6.5	6	5.5
Dimension B	5	4.5	3	5	4.5	3.5	4.5	4
Dimension C	6	6	4.5	5.5	4.5	4.5	3.5	4.5
Dimension D	7	4	4	5	4.5	3.5	3.5	4
Dimension E	5	3.5	3.5	8	6.5	5.5	3.5	5
Dimension F	4.5	3	4.5	5.5	3.5	3.5	3	5.5

SCORER 2

Interviews	One	Two	Three	Four	Five	Six	Seven	Eight
Dimension A	7	6	4	6	6	7	6	6
Dimension B	6	6	3	6	5	4	4	4
Dimension C	7	8	6	8	6	5	6	5
Dimension D	7	5	5	6	6	4	3	5
Dimension E	8	6	6	8	8	5	5	4
Dimension F	7	5	8	8	5	5	5	5

COMBINED SCORES

Interviews	One	Two	Three	Four	Five	Six	Seven	Eight	TOTAL
Dimension A	7	5.5	4.5	6	6	6.5	6	5.5	47
Dimension B	5.5	5	3	5.5	5	4	4.5	4	36.5
Dimension C	6.5	7	5	6.5	5	5	5.5	4.5	45
Dimension D	7	4.5	4.5	5.5	5.5	4	3.5	5	39.5
Dimension E	6.5	5	5.5	8	7	5.5	3.5	4	45
Dimension F	6.5	5	7	6.5	5	4.5	5	5	44.5

CALCULATED SCORES

- Existing Community Efforts (Total dimension A: $47 \div 8 = 5.9$ (initiation))
- Community Knowledge of The Efforts (Total dimension B: $36.5 \div 8 = 4.6$ (preparation))
- Leadership (Total dimension C: $45 \div 8 = 5.6$ (initiation))
- Community Climate (Total dimension D: $39.5 \div 8 = 4.9$ (preparation))
- Community Knowledge About the Issue (Total dimension E: $45 \div 8 = 5.6$ (initiation))
- Resources (Total dimension F $44.5 \div 8 = 5.6$ (initiation))
- Average overall community readiness score = 5.4 (preparation)**

Appendix 14: Participant's Information Sheet (Systems Approach)

Study title: Exploring the feasibility of applying a systems approach to developing childhood obesity prevention interventions in Makkah city, Saudi Arabia.

I would like to invite you to take part in a research study. Before you decide whether to take part, you need to understand why the research is being done and what it would involve for you. This study is part of a doctoral research sponsored by the Ministry of Education in Saudi Arabia. Please take time to read the following information carefully. Ask questions if anything you read is not clear or if you would like more information. Take time to decide whether or not to take part.

1- What is the purpose of the study?

- Current approaches to interventions have failed to halt the rise of obesity and related non-communicable diseases.
- Leading international experts in obesity research are calling for the use of a systems approach to obesity prevention.
- This study aims mainly to explore the feasibility of using a systems approach in your community in order to prevent obesity among children aged 2-18 years.

2- Why have I been invited?

- You are receiving this material either because you are working in a local authority/organisation or a valued member of Makkah community.

3- What will happen to me if I decide to take part?

- Once you have agreed to take part and signed the consent form, I will interview you for around 60 minutes. You can choose the date and time of the interview.
- The interview will be audio recorded with your agreement (all identifying information will be anonymised) and written up so that I can evaluate what has been said.
- The interview will be conducted using an online application such as Skype Business or Microsoft Teams.
- You will be able to withdraw from the study at any time without giving a reason and without any effects. You have the right to request that all information held about you is deleted. However, it may be impossible to delete information once data have been analysed.

4- Do I have to take part?

- Participation in our study is entirely voluntary. If you do decide to take part, you will be asked to sign a consent form. You will be able to withdraw from the study at any time without giving a reason and without any effects. You have the right to request that all information held

about you is deleted. However, it may be impossible to delete information once data have been analysed.

5- Are there any possible disadvantages or risks from taking part?

- The interviews will not ask any sensitive questions, so there are no anticipated risks associated with your involvement in this study.

6- What are the possible benefits of taking part?

- Taking part in this research will not benefit you personally. However, the information you provide is critical to highlight future areas for action regarding childhood obesity in your community as well as things that are being done well.
- If you are a manager/deputy working in local authorities, this research may benefit you on how to promote health and improve the life quality of your community.

7- Will information be confidential?

- **Yes.** All information collected will be treated confidentially. However, confidentiality will be broken if a risk of serious harm to yourself or others is disclosed.
- All data will be stored using a protected- password on the University server (OneDrive) and will be only accessible by the research team.
- Your data will be anonymised entirely. Any identifying features that might be used in order to identify you will be anonymised or eliminated accordingly.
- Your name, position and organisation/authority will also be anonymised and pseudonymised. A pseudonym name and number will be used throughout my thesis and in any other forms of dissemination.
- To ensure confidentiality, you have to be alone in a private room. The interview will not be conducted if there is no a private room.
- The School for Policy Studies Research Ethics committee (SPS REC) at the University of Bristol has approved this research.

8- What will happen to my data?

- Your anonymised transcript will be used in the various outputs (PhD thesis, conferences, publications and presentations).
- The online platform will be used to audio record the interview. The audio recording and transcripts will be stored using a protected password on the University server (One Drive), and the audio recording will be removed from the platform straight after the interview.
- Interview recordings will be transcribed by a native Arabian citizen (myself) in Arabic and only the necessary quotes will be translated into English.
- With your permission, the anonymised transcripts will be deposited/archived in the university's Research Data Repository, data.bris, and it might be used for future research and learning.

- All the data at the end of the study will be stored for 20 years on an appropriate storage facility at the University of Bristol until it is no longer needed when it will be safely shredded or erased.

9- What if there is a problem?

- For any complaints about poor research practice, please contact principal supervisor: Dr Bai Li via Email: bai.li@bristol.ac.uk or P: +44(0)1773310978.

10- Who is organising and funding the study?

- This research is funded by the Ministry of Education in Saudi Arabia and conducted by a doctoral researcher at the University of Bristol.

11- What will happen now?

- If you would like to take part in this study, then please complete the enclosed consent form and return it to the researcher by email.
- Once I have received your consent form, I will contact you to discuss the date and time of interview.

12- Further information and contact details

- Please contact **Mr Mohammed Alharbi; Doctoral Researcher** -the University of Bristol, School for policy studies, Centre for Exercise, Nutrition and Health Sciences. **E-mail:** gk19069@bristol.ac.uk ; **P:** UK: +447366101923, KSA: +966555056670

Appendix 15: The topic guide (Systems Approach)

Questions	Probes
Icebreaker	
<ul style="list-style-type: none"> • What is your role in the local authority/organisation? • What is your background? 	How long have you been in this role?
Part one: Personal Knowledge and experience of childhood obesity programmes	
<ul style="list-style-type: none"> • First, I would like you to tell me about your thoughts on childhood obesity in general. • Have you had any experiences with delivering a childhood obesity programme? 	<ul style="list-style-type: none"> - How important an issue do you think childhood obesity is? -If he/she has had experience with delivering a programme, tell me more about it? If not, why?
Part two: Organisation/local authority experiences of preventing childhood obesity	
<ul style="list-style-type: none"> • You/your local authority/organisation have to deal with many issues of concern to their community. Where is childhood obesity prevention situated in your priority list (pyramid)? • Are your local authority/organisation working, or have you worked with any other organisations for tackling childhood obesity? 	<p>Instructions for the interviewer: if childhood obesity is not, ask about obesity in general, if obesity is not, ask about health promotion to control major health issues closely linked to obesity or share the same risk factors such as type 2 diabetes or hypertension.</p> <ul style="list-style-type: none"> • If he/she answers yes, Tell more about it? Describe your role in this programme? Were there any successes or challenges you can recall? • If he/she answers no, why do you think this is the case?
Part three: perceived benefits, barriers, facilitators and roles in developing systems-based childhood obesity prevention interventions using GMB	
<p><u>Instruction for the researcher: start this part by describing the GMB approach.</u></p> <ul style="list-style-type: none"> • I have previously briefed you on the GMB approach; what are your views on the systems approach? • What would be the potential barriers to applying this new approach to developing childhood obesity interventions in your community? • What would be the potential facilitators to applying this new approach to developing childhood obesity interventions in your community? • Is your organisation/authority willing to take part in developing systems-based intervention using this approach? If yes, what role your organisation/local authority can play in preventing childhood obesity? If not, why? 	<p><u>Probing for the first question on the left:</u> What do you think about the following statement: "an effective and sustainable action to prevent childhood obesity requires participation from and coordination across many different governmental, social and industry organisations?"</p> <p><u>Probing for the 3rd question on the left:</u> With the potential barriers that you have just described, what can we do to reduce or overcome these barriers?</p> <p><u>Instructions for the interviewer about the 2nd question:</u> if cultural or social norms were not mentioned; How about cultural and social norms?</p>
Part four: decision-makers' preferred strategies to optimise the processes of organising and running GMB workshops within the Saudi community	
<ul style="list-style-type: none"> • What do you think would be the best strategies to <u>organise</u> a GMB workshop within the Saudi community? • What do you think would be the best strategies to <u>run</u> a GMB workshop within the Saudi community? 	<p><u>Instruction for the researcher:</u></p> <ol style="list-style-type: none"> 1) Be ready to explain what you expect the person to talk about in terms of 'organising'. Give specific and clear guidance, e.g., do you mean recruitment strategies, how to group participants in a workshop to accommodate cultural/religious issues? Again, be specific, and you are more likely to generate rich user data. 2) If no useful idea is given, tell them about previous contingency GMB options: a) having separate workshops with men and women and then merge the outcomes, b) having a female to run the workshop, and c) virtual workshops. Then ask them what they think about each option. 3) <u>if the participant has participated in GMB workshops: ask about his/her opinion about the workshop.</u>
Closing	
Is there anything else you would like to add?	
Summarise key points discussed for the participant and check those points have been understood correctly and not missing anything important - if time allows	

Appendix 16: Participant information sheet (GMB workshop)

Study title: Exploring the feasibility of group model building approach to developing childhood obesity prevention interventions in Makkah city, Saudi Arabia.

I would like to invite you to take part in a research study. Before you decide whether to take part, you need to understand why the research is being done and what it would involve for you. This study is part of a doctoral research sponsored by the Ministry of Education in Saudi Arabia. Please take time to read the following information carefully. Ask questions if anything you read is not clear or if you would like more information. Take time to decide whether or not to take part.

1- What is the background and purpose of the study?

- Current efforts have failed to tackle obesity. International experts in obesity research are calling for the use of a group model building (GMB) method for obesity prevention.
- GMB is a participatory method for involving different people in different activities to think in a systems way which can improve understanding of complex issues such as obesity.
- The key activities involved in GMB are a) behaviour over time graph, b) connection circles, and c) identifying and prioritising action points.
- GMP method is done through a workshop structure; participants are guided by a series of participatory activities to develop a causal loop diagram (CLD) map.
- This diagram represents the systemic drivers of obesity in a community.
- Finally, participants are working together to identify and prioritise action points based on feasibility and likely impacts.
- This study aims mainly to identify the best way to conduct group model building (GMB) workshops within the Saudi community.

2- Why have I been invited?

- You are receiving this material either because you are working in a local authority/organisation or a valued member of Makkah community.

3- What will happen to me if I decide to take part?

- Once you have agreed to take part in the study, you will be invited to attend 90 minutes an online workshop with different decision-makers and individuals from different sectors.
- We will go through different exercises which will be explained for you by the researcher at the beginning of the workshop.
- At the end of the workshop, you will be asked to fill in a short online feedback survey. This survey is related to the workshop process.
- The workshop will be audio recorded with your agreement (all identifying information will be anonymised) and written up so that we can evaluate what has been said.
- The workshop is planned to be video recorded. However, if not all participants agree to video recording, the researcher will not record the workshop.

- After you agreed to take part and signed the consent form, several options of date and time will be provided to you and other participants.
- The most popular date and time will be selected, and I will inform you of the exact date and time by email/SMS.
- An online software (Skype for Business or Microsoft Teams) will be used to run this workshop, and after you agree to take part, the information about this online software will be sent to you.

4- Do I have to take part?

- Participation in our study is entirely voluntary. If you do decide to take part, you will be asked to sign a consent form. You will be able to withdraw from the study at any time without giving a reason and without any effects. However, if you withdraw during or after the workshop, your inputs in the workshop, anonymous feedback survey, anonymised notes taken by the researcher, quantitative data, audio recording and video recording (if the workshop was video recorded) cannot be withdrawn because most of these data are anonymously collected and incorporated into the general discussion with other participants.

5- Are there any possible disadvantages or risks from taking part?

- The workshop will not discuss any sensitive issues, so there are no anticipated risks associated with your involvement in this study.

6- What are the possible benefits of taking part?

- Taking part in this research will not benefit you personally. However, your participation and the information you provide in this workshop are critical to highlight the issues surrounding GMB workshops within the Saudi community, which in turn inform what needs to improve in order to conduct GMB workshops within the Saudi community.
- This research may certainly benefit the decision-makers as they will experience or at least be introduced a new way of thinking and working to potentially solve a major public health crisis in their community.

7- Will information be confidential?

- Yes. All information collected will be treated confidentially. However, confidentiality will be broken if a risk of serious harm to yourself or others is disclosed.
- All data will be stored using a protected- password on the University server (OneDrive) and will be only accessible by the research team.
- Your data will be anonymised entirely. Any identifying features that might be used in order to identify you will be anonymised or eliminated accordingly.
- The online feedback survey is anonymous and does not collect any identifiable information.
- Survey responses will be exported from "Online Surveys" platform and transferred onto a secure server managed by the University of Bristol.
- The researcher will be taking anonymised notes during the workshops so that he can evaluate later how the workshop process progressed.
- You may be recognised by other participants in the workshop and they will be aware of any comments that you make. All the participants will be asked to

keep the discussions within the workshop confidential and not to reveal the identities of those taking part.

- You will participate with others, so their privacy and responses must be respected and kept confidential.
- Your name, position and organisation/authority will also be anonymised and pseudonymised. A pseudonym name and number will be used throughout my thesis and in any other forms of dissemination.
- The School for Policy Studies Research Ethics committee (SPS REC) at the University of Bristol has approved this research.

8- What will happen to my data?

- Your anonymised transcript will be used in the various outputs (PhD thesis, conferences, publications and presentations).
- The online platform will be used to audio and video record the workshop (if all participants permit to video recording). The recordings and transcripts will be stored using a protected password on the University server (One Drive) and removed from the platform straight after the workshop.
- Workshop recordings will be transcribed by a native Arabian citizen (myself) in Arabic and only the necessary quotes will be translated into English.
- With your permission, the anonymised feedback survey and transcripts will be deposited/archived in the university's Research Data Repository, data.bris, and it might be used for future research and learning.
- All the data at the end of the study will be stored for 20 years on an appropriate storage facility at the University of Bristol until it is no longer needed when it will be safely shredded or erased.

9- What if there is a problem?

- For any complaints about poor research practice, please contact principal supervisor: Dr Bai Li via Email: bai.li@bristol.ac.uk or P: +44(0)1773310978.

10- Who is organising and funding the study?

- This research is funded by the Ministry of Education in Saudi Arabia and conducted by a doctoral researcher at the University of Bristol.

11- What will happen now?

- If you would like to take part in this study, then please complete the enclosed consent form and return it to the researcher by email.
- Once I have received your consent form, I will contact you to discuss the date and time of the workshop. Then, you will be informed about the exact date and time of the workshop.

12- Further information and contact details

- Please contact **Mr Mohammed Alharbi; Doctoral Researcher** -the University of Bristol, School for policy studies, Centre for Exercise, Nutrition and Health Sciences. **E-mail:** ek19069@bristol.ac.uk ; **P:** UK: +447366101923, KSA: +9665550566

Appendix 17: Consent form (For GMB workshop)

Informed Consent for Exploring the Feasibility of Using a Systems Approach to The Development of Childhood Obesity Prevention Interventions in Makkah City, Saudi Arabia

Please tick the appropriate boxes		Yes	No
1. Taking part in the study			
I have read and understood the study information dated [/ /], or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction		<input type="checkbox"/>	<input type="checkbox"/>
I consent voluntarily to be a participant in this study and understand that I can withdraw from the study at any time, without having to give a reason. Also, I understand that I am free to participate in the discussion as much as I feel comfortable with and will never be forced to contribute to the discussion.		<input type="checkbox"/>	<input type="checkbox"/>
I agree to participate in the online short feedback survey at the end of the workshop.		<input type="checkbox"/>	<input type="checkbox"/>
I understand that if I withdraw during or after the workshop, my input in the online workshop, feedback survey, quantitative data, notes taken by the researcher during the workshop, audio recording and video recording (if the workshop was video recorded) cannot be withdrawn.		<input type="checkbox"/>	<input type="checkbox"/>
I agree to the workshop being audio recorded.		<input type="checkbox"/>	<input type="checkbox"/>
I agree to the workshop being video recorded.		<input type="checkbox"/>	<input type="checkbox"/>
I understand that if all participants disagree to video recording, the researcher will not video record the workshop.		<input type="checkbox"/>	<input type="checkbox"/>
I understand that the researcher will take notes during the workshop, and all notes will be anonymised to ensure my confidentiality.		<input type="checkbox"/>	<input type="checkbox"/>
I understand other members of the workshop may be known to me and that I should not disclose the identities of those taking part to any other parties.		<input type="checkbox"/>	<input type="checkbox"/>
I understand that I may be recognised by other participants in the workshop, but they have signed to agree to maintain confidentiality and anonymity.		<input type="checkbox"/>	<input type="checkbox"/>
I understand that the researcher has agreed not to reveal my identity and personal details, including where information about this project is published or presented in any public form.		<input type="checkbox"/>	<input type="checkbox"/>
I understand that confidentiality will be broken if a risk of serious harm to myself or others is disclosed.		<input type="checkbox"/>	<input type="checkbox"/>
2. Use of the information in the study			
I understand that information I provide will be used for a PhD thesis, conferences, publications and presentations.		<input type="checkbox"/>	<input type="checkbox"/>
I understand that personal information collected about me that can identify me, such as my name or where I live/work, will not be shared beyond the study team.		<input type="checkbox"/>	<input type="checkbox"/>
I agree that my information can be anonymously quoted in research outputs.		<input type="checkbox"/>	<input type="checkbox"/>
I understand that access to the workshop data including feedback survey, notes, audio and video recordings (if the workshop was video recorded) will be limited to the research team.		<input type="checkbox"/>	<input type="checkbox"/>
3. Future use and reuse of the information by others			
I give permission for the anonymised feedback survey that I provide to be deposited in the University's Research Data Repository, data.bris so it can be used for future research and learning.		<input type="checkbox"/>	<input type="checkbox"/>
I give permission for the anonymised transcript from the workshop I take part in will be deposited in the University's Research Data Repository, data.bris so it can be used for future research and learning.		<input type="checkbox"/>	<input type="checkbox"/>
4. Signatures			
Name of participant	Signature	Date	
_____	_____	_____	
I have accurately read out the information sheet to the potential participant and, to the best of my ability, ensured that the participant understands to what they are freely consenting.			
Name of researcher	Signature	Date	
Mohammed Alharbi	_____	_____	
5. Study contact details for further information			
Mohammed Alharbi; P: +447366101923; Email: gk19069@bristol.ac.uk			
Lead Supervisor: Dr Bai Li; P: +44(0)1773310978; Email: bai.li@bristol.ac.uk			

Appendix 18: Presentations slides of the virtual GMB workshop

Group Model Building Workshop

By Mohammed Alharbi
FAD Candidate
Centre for Exercise, Nutrition and Health
School for Policy Studies

Supervised By:
Bill Li and Charlie Foster
Centre for Exercise, Nutrition and Health
School for Policy Studies

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Outlines

- Part I: Childhood Obesity In Saudi Arabia.
 - Complexity of Childhood obesity and the need for a systems approach
 - The GMB method.
- Part II: Workshops Activities.
- Part III:
 - Feedback
 - Evaluation Form.

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Childhood Obesity in Saudi Arabia

Prevalence

- The Saudi prevalence of obesity among children aged 5-19 years:
 - From 13.8% in 2009 to 17.5% in 2016,
 - in 2030, more than 1.8 million affected.

Economic

- Expected to reach over US\$ 19 billion, nearly 2.5 of the Saudi GDP

Efforts

- Fragmented and appear mostly as short-term attempts.
- Traditional methods, focusing on individual level, linear cause-effect.
- Recently, a number of policies is either already adopting or is planning to enact.


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>What is a systems approach?

- Considering the whole as well as the parts
- Fix the entire system, not just parts of it.

>Why use it?


- The complexity of obesity
- The failure of past approaches



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Group Model Building

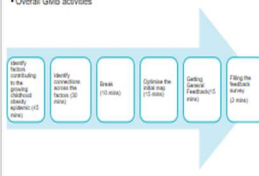
- Representatives from diverse subsystems of the target community take part in a series of interactive workshops to co-produce a diagram that shows the complex interrelationships across different drivers of childhood obesity in the target community.
- This map helps to identify and prioritise systemic interventions
- An intervention won't work, or sustain if major stakeholders such as governments or manufacturers are not on board.



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GMB Workshop

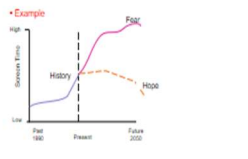
- Overall GMB activities



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Activity 1: Drawing graphs showing changes over time

Example



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Activity 1

- Work style: Individually
- Your needs: a piece of paper and a marker (blank behaviour over time that I sent in the PDF)
- Your tasks: Draw as many graphs as you can (one graph for one factor only) for other factors that have contributed to the growing childhood obesity prevalence in this city
- Time: 15 minutes

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Cont. Activity 1

- Work style: group (breakout room feature)
- Your tasks:
 - Take your group, completed graphs and describe your graphs to the other members and then put them in priority order.
 - Record your group number when I send you to the breakout room
 - Select somebody to report back
- When we come back together what I'm going to do is ask each group to give me their top priority to start the second activity.
- Time: 30 minutes

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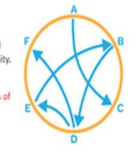
Seeing identified factors on the screen

- I will listen to each participant's description for each factor and help them to define the right name for each suggested factor.
- We need to make sure that the factor names do not indicate direction of change.
- Each defined factor is entered into STIKKE in five.
- Time: 30 minutes

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Activity 2: Identifying connections across factors

- Let's identify connections across the identified factors that contribute to childhood obesity in the local community.
- Arrows are used between factors to indicate directions of connections.



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Break-5 Minutes



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Activity 3: Optimising the initial map

- Now, we have an initial map showing various contributing factors and their complex relationships.
- Your tasks:
 - To review the current map and see if it makes senses (reflect the situation in this community)
 - To consider if new factors should be added
 - To consider if any factors should be removed or renamed
 - To identify new connections

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General Feedback

Amazing together we have tested some of the GMB process for the first time in this country! Thank you for your contribution! Now welcome, honest, verbal feedback from you.

- What do you think in general about this workshop?
- What do you think the main benefits or strengths of these activities are?
- Which parts of this workshop were easy to understand and take part?
- Which parts of this workshop were more difficult to understand or take part? Why? How can we improve them?
- Do you think when the map is finalized (usually this will involve at least one more workshop with representatives from diverse sectors and departments), policy makers are able to identify and prioritise potential interventions?
- If policy makers are able to determine broad intervention themes (jointly in a later workshop following the current stage which we have tested together) just now, do you think policy makers are willing to form Action Groups?

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Activity 6: Filling the feedback survey

- Click on the link and filling the survey.
- Time: 2 mins.
- After finishing the survey, please come back.

<https://qps.onlinesurveys.ac.uk/feedback-survey-for-the-online-gmb-workshop>

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Thank You For Your Attendance



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Appendix 19: The online evaluation form

1. I am working at * Required

- Governmental Authority (Non Health)
- Governmental Health Authority
- Education and Research Centres
- Non-Profit Organisations
- Private Sectors
- Other

2. I liked the way I was invited to join workshops with other representatives. * Required

- Strongly disagree
- Disagree
- Neither agree nor disagree
- Agree
- Strongly agree

3. I found key activities easy to understand and I can teach/explain them to others. * Required

- Strongly disagree
- Disagree
- Neither agree nor disagree
- Agree
- Strongly agree

4. What parts of the process (if any) were the hardest to understand and participate in? * Required

- Identifying factors contributed to childhood obesity
- Connections across factors
- Optimising the initial map
- Other

5. What parts of the process (if any) were the easiest to understand and participate in? * Required

- Identifying factors contributed to childhood obesity
- Connections across factors
- Optimising the initial map
- Other

6. I think this approach would be useful and feasible in real-world within the Saudi community. * Required

- Strongly disagree
- Disagree
- Neither agree nor disagree
- Agree
- Strongly agree

7. I would be willing to participate in real workshops (not online). * Required

- Yes
- No
- Not sure

8. If you have anything to add regarding benefits, limitations and how it could be improved, please use this space.