UNIVERSITY OF Hull

Pathways to Colorectal Cancer Screening in Hull: A Complexity Informed Configurational Approach

PhD Dissertation

Esmaeil Khedmati Morasae

(MSc in Public Health, Tehran University of Medical Sciences, Iran)

Supervisors

Prof. Yasmin Merali

Prof. Una Macleod

September 2018

Acknowledgements

My PhD path and this dissertations were not possible to emerge and evolve without precise, helpful, and insightful guidance and assistance of my great supervisors, Professor Yasmin Merali and Professor Una Macleod. From conception of research ideas about application of a complexity-informed approach to screening behaviour to challenges of data gathering, analysis, interpretation, and write-up, I have had the privilege of their warm support and guide. Hereby, I cordially thank them for all their support, help, effort, and guide. Looking at world through a complex systems point-of-view is the most precious gift that they granted and cultivated within me and I am thankful for that from bottom of my heart.

Dedication

This PhD dissertation should be dedicated to my lovely parents and sisters who supported and encouraged me to leave the country and follow my bliss, when the opportunity of doing a PhD in UK knocked at our family door. Millions of heartfelt thanks for their limitless kindness and support over these years.

My life has been extra-lit by dawn of a lovely shining star since June 2017 when I met my lovely wife, Negin. Her warm and soulful support and cheer-up has been a gushing source of encouragement for me. Thank you very much my lovely Negin for your presence and inspiration.

I shall also thank all my lovely friends and Hull University staff who have helped me through the PhD process with their kind guide and help. Especially, I feel obliged to thank Dr. Daniel Jones who helped me a lot in contacting with GP practices and finding the patients for interviews.

Abstract

In terms of its colorectal cancer profile, Hull is among the worst cities in the UK. A considerable number of colorectal cancer cases in Hull are diagnosed in emergency departments and in their late stages. Several modalities of screening tests (e.g. Faecal Occult Blood Test (FOBT)) are offered in order to detect cancer cases in their early days of development when treatment is more feasible. However, the overall rate of screening is far from optimal and is even lower among people of lower socioeconomic status in Hull. Despite Hull having such an unacceptable profile of colorectal cancer, very few studies have investigated the reasons behind screening behaviour and its unequal distribution in Hull. This study, therefore, aimed to understand the reasons behind screening behaviour and its inequalities in this city. Unlike conventional research focusing on the impact of single psychosocial factors on screening, we used a complexity-informed configurational approach, called Qualitative Comparative Analysis (QCA), to understand the configurations of conditions that produce screening behaviour. Semi-structured interviews were conducted with 30 people from the most and least deprived neighbourhoods in Hull to gather the required data. A thematic content analysis was undertaken to discover the main themes (conditions) that were reported as the determinants of screening by participants. Various configurations of these conditions (complex solutions) were shown by QCA to be sufficient for production of outcome (screening) among the rich and poor. Interestingly, the number of configurations for production of outcome negation (lack of screening) was higher among the poor. Moreover, minimization of complex solutions showed that motivation is the most important (highly necessary and sufficient) condition influencing the screening decision in Hull, regardless of socioeconomic status. Therefore, motivation-focused interventions should be in the first line of interventions to increase screening rates and redress inequalities in this city. However, alongside specific attention to motivation and by taking a complex configurational approach, complex

interventions should be designed to address the revealed configurations in each specific socioeconomic context within the city.

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Introduction

1. Background

1.1. Cancers

Cancers are among the leading causes of morbidity and mortality globally, with approximately 14 million new cases and 8.2 million deaths each year. Although there have been some improvements in cancer care and treatment, the incidence of cancers has been steadily increasing during recent years. The number of new cases is expected to rise by about 70% over the next two decades (Stewart and Wild, 2014). More than 331,000 people are diagnosed with cancer in the UK annually. Breast, lung, prostate and colorectal cancers together account for over half of cancer cases in the UK. The most common cancers among men in the UK are as follows: prostate, colorectal, and lung cancers. The most common cancers amongst women in the UK are as follows: breast, lung and colorectal cancers. Overall, cancer incidence rates in UK have increased by more than 30% since the mid-1970s; in fact, cancer incidence rates in Great Britain have risen by 23% in males and by 43% in females since the mid-1970s (Cancer, 2015).

Hull city, generally speaking, is amongst the worst UK local regions in terms of cancer screening, early detection, incidence, survival (cancer continuum), and related lifestyle factors (Table 1). Although there is little scientific evidence explaining or justifying such a situation, there are some postulations that the reason behind Hull's unfavourable profile in terms of cancer (and public health generally) might be its higher deprivation levels compared with other parts of the UK (Hull, 2016).

1.2. Colorectal cancer

Taking both sexes into consideration, colorectal cancer (CRC) is the 3rd most common cancer globally(Stewart and Wild, 2014). The number of colorectal cancer cases has been steadily increasing over the last 40 years in the world and in the UK. Colorectal cancer is the fourth most common cancer in the UK, accounting for almost 13% of all new cases. It

is the 3rd most common cancer among men (14%) and women (11%), respectively. The lifetime risk of developing colorectal cancer in the UK is around 1 in 14 for men and 1 in 19 for women. There are around 42,000 new cases of colorectal cancer in the UK annually, 51% among men and 49% among women. Over 90% of colorectal cancers occur among people of over 50 years old (Cancer, 2015).

The incidence of bowel cancer in Hull is close to the UK's national average incidence (46.5 per 100,000), but the bowel cancer mortality rate in Hull (19.6 per 100,000) is higher than the national average (16.4 per 100,000) and among the worst in the country (Hull, 2016).

Table 1. Cancer statistics for Hull compared to national average

	Hull	National average
Screening (%)		
Cervical screening (25-49)	75.5	71.5
Cervical screening (50-64)	77.4	77.5
Bowel screening	57.4	58.8
Breast screening	70.1	76.4
Lifestyle (%)		
Smoking	29.8	19.5
Alcohol	24.7	20.1
Overweight/Obesity	60.2	63.8
Cancer organ (per 100,000)		
Lung cancer	85.1	47.7
Breast cancer	124.7	125.7
Colorectal (bowel) cancer	47	45.5
Prostate cancer	111.6	105.8
Cervical cancer	14.6	8.8
Ovarian cancer	17.1	16.7
Stomach cancer	13.7	8.4

1.3. **Colorectal cancer screening**

Bowel cancer screening tries to detect bowel cancer at an early stage when treatment is more likely to work. It can also prevent bowel cancer from developing in the first place (primary prevention). There are different modalities to screen for colorectal cancer, namely Faecal Occult Blood Test (FOBT), colonoscopy, and flexible sigmoidoscopy (FS). People of 50 to

75 years old are recommended to follow one of the following routes of screening: colonoscopy every 10 years; FS every five years along with an FOBT every three years; or an FOBT every year (Stewart and Wild, 2014).

The low rate of colorectal cancer screening among men and women, compared with other cancers, has been of great interest for health scientists and policy makers and there are some calls for more precise studies about this issue. Some scientists believe that existence of more than one modality for screening might lead to confusion and delay in uptake. However, the fact that only FOBT is currently offered in the UK, where such a difference in screening participation for different cancers holds, refutes the proposed explanation (Wardle et al., 2015).

Bowel screening centres in the UK use Faecal Occult Blood Testing (FOBT) to screen for colorectal cancer. These centres send a testing kit to eligible people once every 2 years. The test is done by the person at home, using the testing kit. After sending the kit back to the centre, the result is sent back to the person. Most people have a clear normal FOBT result and carry on with their normal life. Some people get an unclear test result, showing that there was a slight suggestion of blood traces in the faeces. These people will get another testing kit and a recommendation to do the test again. However, out of 1,000 people who take the test, only 20 (2%) will have an abnormal result (in the UK). Around 16 of those 20 people will be sent for colonoscopy to check their situation more precisely. Approximately 8of these people will have no abnormal result, 6 will have polyps, and 2 will have cancer (Cancer, 2015).

Studies have shown that if colorectal cancer is diagnosed at an early stage, over 90% of patients will live more than 5 years. It is also shown that screening people between 45 to 74 years old with FOBT will decrease the chance of dying of colorectal cancer by 16% (2000 deaths each year in the UK) (Cancer, 2015).

1.4. **CRC screening distribution**

The success of a high-quality, organised, and population-based CRC screening programme depends on adequate uptake as well as social equity in uptake (Coombs A, 2002). Evidence has indicated a social gradient in colorectal screening uptake in various societies (Whynes et al., 2003, Weller et al., 2007, von Wagner et al., 2011a, Weller and Campbell, 2009). Globally speaking, participation in CRC screening tends to be lower among ethnic minorities (Weller and Campbell, 2009, Javanparast et al., 2010), people of low socioeconomic status (Weller et al., 2007, von Wagner et al., 2011b, Honein-AbouHaidar et al., 2013, Molina-Barcelo et al., 2011), and men (Molina-Barcelo et al., 2011, Honein-AbouHaidar et al., 2013, Christy et al., 2014). As a result, there is a compelling need for research aimed at understanding the processes underpinning the observed socio-demographic patterning of screening behaviour to inform the development of programs to address inequalities (Chor et al., 2014, Damiani et al., 2012, Niederdeppe and Levy, 2007, Brenna et al., 2001, Beeker et al., 2000).

There is also reliable evidence that CRC screening is unequally distributed in the UK, at both individual and area levels (Raine et al., 2016a, Beeken et al., 2011). In a study in the UK, the number of first round FOBT kits returned for the least and most deprived areas were 49% and 32%, respectively (von Wagner et al., 2011a). Another recent study showed that 35% of people living in the most deprived areas and 61% of people living in the least deprived areas take part in the NHS national CRC screening program, and there is a direct relationship between socioeconomic deprivation and CRC screening, with a strong effect among women and older people. Areas with a higher proportion of minority ethnic groups also showed a lower participation in screening programs (Beeken et al., 2011). However, there is a lack of studies about the mechanisms and reasons behind such inequalities in screening behaviour in UK. For example, a recent national study has shown that there is a

significant pro-rich inequality in CRC screening in the UK and the inequality is mostly explained by wealth (accounting for about 40% of inequality), partner screening status (16%), sickness/disability (13.5%), and health literacy (8.5%) (Raine et al., 2016a). However, there is still a need for more research in this regard.

The proportion of people attending colorectal cancer screening in Hull is slightly lower than the national average (56.7% to 58.3%). Also, recent evidence shows that just as in other parts of the UK, there is a gradient in uptake of CRC screening so that the rate of screening in the least deprived populations is around 64%, while it is under 50% in the most deprived population (Hull, 2016). However, there has been no research on the reasons behind such inequalities in Hull to date.

1.5. **Research gap and rationale for this study**

In general, while social inequities in CRC screening uptake are well-described in the literature (Jepson et al., 2000, Beydoun and Beydoun, 2008), there is a lack of clear understanding of why CRC screening does or does not appeal to individuals of different backgrounds (Honein-AbouHaidar et al., 2016). In fact, given the ease of use of FOBT kits and the fact that their use imposes no cost or harm, inequalities in uptake are very striking. Trials have shown that colorectal screening can lead to a reduction of 6% to 33% in colorectal cancer incidence and mortality (Mandel et al., 1993, Kronborg et al., 1996, Hardcastle et al., 1996, Hewitson et al., 2008), and this is among the highest rates for all cancers with a screening program. Therefore, health systems should take advantage of such an opportunity and redress any unjust inequality observed in CRC screening uptake.

Consequently, considering the fact that FOBT has recently been scaled-up (from 2010) to become a UK-wide population-based program, and given the calls for more research about its inequalities, the present study aimed to apply a complexity-informed configurational

approach to better understand the determinants of CRC screening uptake and its inequalities in Hull city.

Generally speaking, the reasons suggested in the literature for inequalities in CRC screening can be grouped into three overall categories of individual, social, and provider factors. By individual factors, public health scholars refer to psycho-cognitive determinants of cancer screening participation. Some of the individual factors that are highly investigated in screening literature are as follows: negative attitudes to and expectations of undergoing the test (e.g. test aversion and embarrassment etc.), fatalistic beliefs about CRC (e.g. no one can reduce the risk), fear of cancer diagnosis, and lack of knowledge about screening and the benefits of early cancer detection (Honein-AbouHaidar et al., 2016). Gender, age, socioeconomic status, race/ethnicity, religion, place, and acculturation normally act as social determinants of screening. Physician endorsement and structural barriers (like access and insurance coverage) in healthcare systems are known as provider-related determinants of screening. Interestingly, research about CRC screening behaviour and inequalities has so far been mostly channelled into studying SES differences in individual-level beliefs and attitudes to screening, either through large quantitative or detailed qualitative studies. The ease and simplicity of revealing such individual features and the sheer complexity of capturing and integrating broader social factors are the forces behind this over-focus on individual-level factors. However, even revealed individual factors are inconsistent, uninterpretable, and defy incorporation into a solid body of knowledge to create a framework for understanding and reducing the inequalities. In fact, taking a critical stance, one can say that due to the reductionist and decontextualized perspective inherent in research on these factors, the literature conveys a sense of disconnectedness and a lack of an integrative, configurational, and holistic approach regarding reasons behind screening behaviour. Indeed, against our true integrative and configurational humanistic nature and

experience, the research undertaken to date has tried to explore the behaviour of screening within three disconnected realms of psychological, social, and structural inquiry and this needs to be modified in future research (Short and Mollborn, 2015).

As has been shown, proximal psycho-cognitive determinants of CRC screening have been extensively studied, but only a small number of studies have examined whether they truly explain SES differences in screening up-take (Wardle et al., 2004, Lantz et al., 1997, Stein et al., 1991, Stein et al., 1992, Abraido-Lanza et al., 2015). Commenting on the dearth of evidence on this area, Leganger and Kraft hold that although it is generally accepted that psycho-cognitive factors mediate the relationship between SES and cancer screening behaviour, few studies have embarked to investigate this issue empirically and the whole chain or configuration from social factors to cognitive features to screening behaviour is rarely addressed (Leganger and Kraft, 2003). However, some studies that have examined pathways between SES and cancer screening provide some interesting insights. Stein et al., for example, studied inequalities in mammography use among urban women in USA, showing that perceived cost, pain and embarrassment partly mediated the relationship between SES and mammography (Stein et al., 1992). Lantz et al. extended this work by separating cost and psychological barriers from each other and progressively controlling for these mediators in a study on mammography and pap-smear tests (Lantz et al., 1997). They eventually reported that economic barriers account for only part of the association. However, a subsequent simulation showed that removal of these barriers has only a slight effect on inequality if beliefs about the screening are not changed. These findings are in line with a study on CRC screening in the UK in which researchers found that the gradient between SES and screening was significantly mediated by perceived benefits and barriers, cancer fear, and fatalistic beliefs about cancer (Wardle et al., 2004).

Generally speaking, the aim of such pathway-based models has been to explain why people of lower economic status perceive cancer screening tests as more threatening, more difficult to accomplish, and less beneficial. These researchers believe that a better understanding of the mechanisms through which lower SES causes negative attitudes toward screening could facilitate the development of intervention strategies to reduce screening inequalities. Some studies, accordingly, have tried to develop frameworks to explain how socioeconomic status and attitudinal factors are related to each other (Beeken et al., 2011, Abraido-Lanza et al., 2015, Miles et al., 2011, Wardle et al., 2004). However, most of these frameworks have not yet been empirically analysed. Two of the most cited frameworks will be explained further in the following section.

Von Wagner and colleagues developed a framework (Figure 1) to link upstream socioeconomic status factors to downstream psychological and individual factors associated with cancer screening (von Wagner et al., 2011b). According to this framework, socioeconomic factors and lived experiences shape attitudinal factors regarding screening. These attitudinal factors mostly relate to risk and threat perceptions and self-efficacy beliefs. These attitudinal factors then shape beliefs about response efficacy and abilities to understand information. They also shape the goal-setting abilities that may finally lead to screening behaviour. Although the framework is developed by referring to available evidence, it has drawbacks. For example, there is little evidence for the importance of self-efficacy in screening for colorectal cancer, specifically when it is administered through FOBT (Honein-AbouHaidar et al., 2016). More importantly, the framework assumes that the pathway described applies to all people from various socioeconomic levels and is the only pathway possible and available.

After a very comprehensive systematic review, Honein and colleagues also developed a framework (Figure 2) to illustrate the factors that influence decisions to participate in

colorectal cancer screening (Honein-AbouHaidar et al., 2016). According to this framework, awareness is the main determinant of screening behaviour, located centrally among various facilitators and barriers. The barriers are cancer fear, test aversion, and fatalism. The facilitators are social network, self-motivation, and public education. However, although this framework stems from a comprehensive systematic review, it has deficits as well. Namely, just as with the previous framework, it does not show how these factors combine in different populations, especially among the rich and the poor. In other words, the developers assume that this framework works in the same way for all populations and that this is the only pathway that exists in reality. This assumption, however, can act as an impediment to attempts to design interventions for specific groups using this framework. Interestingly, in a comprehensive literature review it was found that interventions which *were effective* in increasing screening rates were as follows: invitation appointments, letters and telephone calls, telephone and face-to-face counselling, and removal of financial barriers (e.g. transport and postage costs); measures that *might be effective* were home visits, opportunistic screening, community interventions, simpler screening procedures, and follow-up prompts; interventions that had *limited effectiveness* were printed and audio-visual educational materials, educational sessions, risk-factor questionnaires; and interventions that were *ineffective* were those that used personal rewards or incentives (Jepson et al., 2000). These findings can be challenging for the abovementioned frameworks, mainly for that of Honein and colleagues, who put awareness at the centre of factors influencing the screening decision, as educational measures seem to have limited effect on increasing screening rates (Honein-AbouHaidar et al., 2016).

These investigations all show, as some scientists have indicated, that we need new approaches regarding the determinants of cancer screening behaviour and related interventions (Short and Mollborn, 2015). Critically speaking, one can say that research on

the determinants of cancer screening generally, and of CRC screening specifically, suffers from the following deficits:

(1) Dominance of reductionist and decontextualized approaches: conventional studies on colorectal cancer screening usually look for the independent effect of each variable, especially psycho-cognitive variables, on screening behaviour. Therefore, they parse out the variables from their social context and become blind to the relationships that variables have with each other and with the context. This can affect the studies of inequalities in an especially negative way, as social context is of high importance for such inequalities.

(2) Lack of a configurational perspective: following from such a reductionist view of the context and relationships in conventional studies, the possibilities of having different combinations/configurations of variables that can produce the outcome are also ignored in these studies. In other words, the possible ways in which an outcome can reveal itself become very limited in these studies. One could even say that these studies are somehow averse to pathway-driven thinking as it challenges their reductionist approach.

Against such a background of reductionism, lack of attention to context, and lack of configurational thinking about the factors that influence colorectal cancer screening, the authors of the present study aimed to conduct a local study of the determinants of colorectal cancer screening in Hull, using a complexity-informed configurational approach. It was hoped that this approach would bear more fruitful insights into colorectal cancer and its inequalities in this city.

2. Study objectives

2.1. **Aim**

The present study aims to understand the reasons behind CRC screening behaviour among Hull residents who live in the least and most deprived areas. To be precise, the researcher

aims to understand configurations (pathways) of factors (conditions, either social or individual) that lead to (unequal) screening behaviour in the most and least deprived areas in Hull. The research questions, accordingly, are as follows.

2.2. **Research questions**

1) What conditions (themes) have a role in (or contribute to) CRC screening behaviour in Hull?
2) What configurations of those conditions lead to screening?
3) What configurations of those conditions do not lead to screening?
4) What configurations of conditions lead to screening among the people living in the most deprived areas in Hull?
5) What configurations of conditions do not lead to screening among the people living in the most deprived areas in Hull?
6) What configurations of conditions lead to screening among the people living in the least deprived areas in Hull?
7) What configurations of conditions do not lead to screening among the people living in the least deprived areas in Hull?

3. Knowledge contributions

Generally speaking, by answering these questions, we hope that we can fill some current gaps in the literature in various ways: first, using a complexity-informed configurational approach we will show how in many ways the conditions can sit together (configure) to produce (or not produce) the CRC screening behaviour among people of higher and lower socioeconomic status in Hull. Interestingly, to the best of our knowledge, this is the first study about the determinants of CRC screening in Hull. This could help health policymakers in Hull to devise strategies to raise the rate of CRC screening in Hull and decrease inequalities.

Second, this study can add to international knowledge by its pathway- and configurational-oriented approach. As stated above, most studies about colorectal screening behaviour carried out so far have had a reductionist and non-configurational approach to screening behaviour, even in qualitative studies. Our study can demonstrate how different configurations of conditions can lead to screening behaviour in a specific context (in interaction with the context). In fact, this complex and configurational approach to CRC screening is the added value of our study internationally.

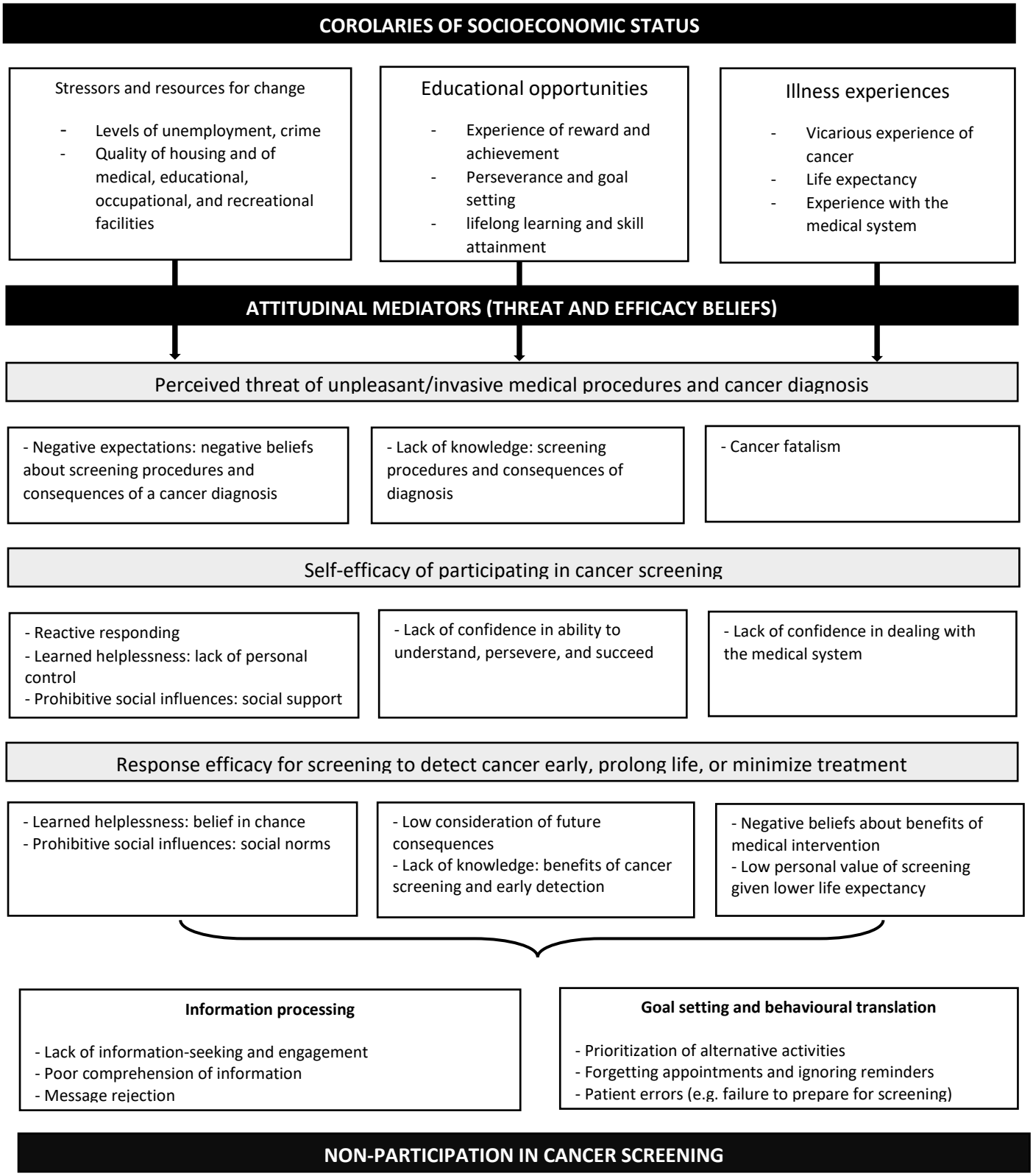


Figure 1. A framework for linking socioeconomic status with psychosocial predictors of screening

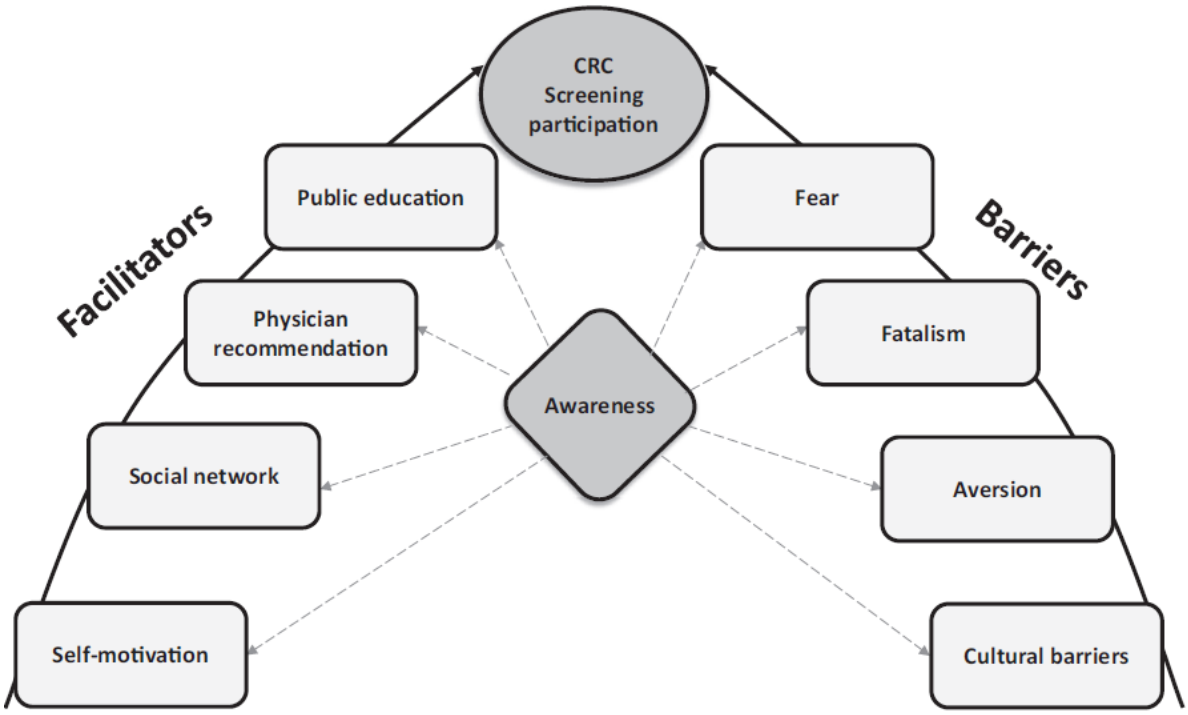


Figure 2. A framework of factors that influence the decision to participate in CRC screening

Literature Review

As it was mentioned in the introduction chapter, screening can lead to a reduction in morbidity and mortality because of colorectal cancer (Cancer, 2015). Nevertheless, the rate of screening uptake is low. As a result, there has been a somewhat long history of research on colorectal cancer (CRC) screening behaviour and its determinants. Such research has gradually added helpful insights to our repertoire of knowledge of the determinants of CRC screening behaviour. In the following section, there will be a review of the relevant studies undertaken so far, especially the qualitative studies that aimed at a deeper understanding of reasons for CRC screening behaviour. Qualitative studies are the main focus as the present study is mainly of a qualitative and configurational nature.

The chapter is organized by factors (conditions or variables) that are reported to be of importance for colorectal cancer screening behaviour in the reviewed literature. Table 2 summarizes the findings of the conducted literature review. As the table shows, the conditions influencing the screening behaviour can be categorized as facilitators and barriers.

Table 2. A sketch of conditions influencing CRC screening behaviour, as facilitators and barriers, according to the reviewed literature

Condition		Explanation	Reference examples
Facilitators	Awareness	Awareness of screening (its indication and periodicity) and its purpose (e.g. lack of symptom does not mean you are healthy)	(Javanparast et al., 2012, Severino et al., 2009, Molina-Barcelo et al., 2011, Shokar et al., 2005, Wackerbarth et al., 2005, Winterich et al., 2011, Oster et al., 2013, Chapple et al., 2008, Gwede et al., 2011, Ogedegbe et al., 2005, Ramos et al., 2013, Baron-Epel

			and Klin, 2009, James et al., 2011, Ge et al., 2009, Dharni et al., 2017)
	Risk perception	Correct risk perception about chance of getting colorectal cancer	(Palmer et al., 2008, Rees et al., 2008, Kiviniemi et al., 2011)
	Positive attitude towards test	Positive attitude towards screening test (convenience, non-invasive, non-painful)	(Aubin-Auger et al., 2011, Beeker et al., 2000, Winterich et al., 2011, Goel et al., 2004, O'Malley et al., 2004, Clavarino et al., 2004, Goodman et al., 2006, Greiner et al., 2012, Foo et al., 2011, Greiner et al., 2005, Frew et al., 2005, Hou, 2005, McQueen et al., 2009, Palmer et al., 2010, Woodrow et al., 2008, Dharni et al., 2017)
	Motivation	(a) Peace of mind (b) Being proactive about one's health (c) Having a close person with CRC	(Palmer et al., 2008, Clavarino et al., 2004, Manne et al., 2012, Palmer et al., 2014, Ekberg et al., 2014, Molina-Barcelo et al., 2011, Beeker et al., 2000, Holmes-Rovner et al., 2002, Lobchuk et al., 2012, Goodman et al., 2006, Holt et al., 2009, Greiner et al., 2012, Severino et al., 2009, Oster et al., 2013, Oscar, 2009, Jilcott Pitts et al., 2013, Bong and McCool, 2011,

		(d) Spouse, family, and friends as motivator	Chapple et al., 2008, Tarasenko et al., 2011, Frew et al., 2005, Weitzman et al., 2001, Bass et al., 2011, Varela et al., 2010, Gwede et al., 2011, Robb et al., 2008)
	Physician recommendation	Communication and recommendation of the test by physicians	(Aubin-Auger et al., 2011, Holt et al., 2009, Oscar, 2009, Jilcott Pitts et al., 2013, Clavarino et al., 2004, Chapple et al., 2008, Gwede et al., 2011, Hoffman-Goetz et al., 2008, Ogedegbe et al., 2005, Feeley et al., 2009, Varela et al., 2010, Goodman et al., 2006, Francois et al., 2009, Ramos et al., 2013, Dubé et al., 2005, Weitzman et al., 2001, Lasser et al., 2008b, Ge et al., 2009)
	Family history	Family history of colorectal cancer	(Rees et al., 2008, Subramanian et al., 2004, Ruffin et al., 2009, Holden et al., 2010, Javanparast et al., 2010, Aubin-Auger et al., 2011, Beyer et al., 2011, Bong and McCool, 2011, Ait Ouakrim et al., 2013)

	Previous experience	Previous positive experience	(Chapple et al., 2008, Aubin-Auger et al., 2011, Garcia et al., 2011, Ekberg et al., 2014, Dharni et al., 2016)
Barriers	Lack of awareness	Lack of awareness of screening and its purpose	(Garcia et al., 2011, Goel et al., 2004, Beeker et al., 2000, Holmes-Rovner et al., 2002, Palmer et al., 2008, Shokar et al., 2005, Greisinger et al., 2006, Goldman et al., 2009, Jones et al., 2010, O'Malley et al., 2004, Sly et al., 2013, Varela et al., 2010, Oscar, 2009, Jilcott Pitts et al., 2013, Chapple et al., 2008, Goodman et al., 2006, Holt et al., 2009, Greiner et al., 2012, James, 2013, Francois et al., 2009, Ramos et al., 2013, Dubé et al., 2005, Foo et al., 2011, Greiner et al., 2005, Hou, 2005b, Weitzman et al., 2001, Royak-Schaler et al., 2004)
	Risk perception	Biased risk perception (under-estimation of the risk) about chance of getting colorectal cancer	(Severino et al., 2009, Ekberg et al., 2014)

	Negative view about cancer	(a) Fear of cancer, screening results, and suffering (b) Fatalistic views about cancer	(O'Malley et al., 2004, Greisinger et al., 2006, Ritvo et al., 2013, Javanparast et al., 2012, Goldman et al., 2009, Jones et al., 2010, Varela et al., 2010, Coronado et al., 2006, Oster et al., 2013, Lee and Lee, 2013, Oscar, 2009, Jilcott Pitts et al., 2013, Clavarino et al., 2004, Oster et al., 2015, Ekberg et al., 2014, Chapple et al., 2008, Holt et al., 2009, Gwede et al., 2011, Francois et al., 2009, Green et al., 2008, Palmer et al., 2014, Ogedegbe et al., 2005, Foo et al., 2011, Greiner et al., 2005, Hou, 2005b, Garcia-Dominic et al., 2012, Tarasenko et al., 2011, Baron-Epel and Klin, 2009, Javanparast et al., 2012, Shokar et al., 2005, Sly et al., 2013, Ge et al., 2009, Dharni et al., 2017)
			(Aubin-Auger et al., 2011, Hoffman-Goetz et al., 2008, Foo et al., 2011, O'Malley et al., 2004, Sly et al., 2013, Varela et al., 2010,

	Negative attitude towards test	(a) Aversion towards the test (b) Awkwardness of the test pack (c) Little belief in efficacy of the test	Denberg et al., 2005, Oster et al., 2013, Jilcott Pitts et al., 2013, Greiner et al., 2012, Francois et al., 2009, Gwede et al., 2011, Robb et al., 2008, Palmer et al., 2014, Ogedegbe et al., 2005, Hou, 2005b, Tarasenko et al., 2011, Frew et al., 2005, Weitzman et al., 2001, Reeder, 2011, Friedemann - Sánchez et al., 2007, James et al., 2011, Royak-Schaler et al., 2004, Woodrow et al., 2008, O'Malley et al., 2001, Clavarino et al., 2004, Coronado et al., 2006, Greisinger et al., 2006, Dharni et al., 2017)
	Lack of motivation	(a) Having a close person with cancer or negative experience of screening (b) Other health or life priorities	(Molina-Barcelo et al., 2011, Fernandez et al., 2008) (Brouse et al., 2004, Beeker et al., 2000, Palmer et al., 2008, Jones et al., 2010, Lobchuk et al., 2012, Ogedegbe et al., 2005, Wackerbarth et al., 2008, Chapple et al., 2008, Sly et al., 2013, Varela et al., 2010, Denberg et al., 2005,

			Oscar, 2009, Jilcott Pitts et al., 2013, Clavarino et al., 2004, Foo et al., 2011, Weitzman et al., 2001)
	Lack of physician recommendation	Lack of recommendation by a physician to do the test	(Beyer et al., 2011, Coronado et al., 2006, Denberg et al., 2005, Oster et al., 2013, Ekberg et al., 2014, Lobchuk et al., 2012, Manne et al., 2012, Gwede et al., 2011, Green et al., 2008, Wackerbarth et al., 2008, Tarasenko et al., 2011, Good et al., 2010, Lasser et al., 2008b, Fyffe et al., 2008, Reeder, 2011, Aubin-Auger et al., 2011) (Lasser et al., 2008b, van Dam et al., 2013)
	Contextual factors	Lower socioeconomic status, gender, ethnicity, low health literacy, and language difficulties	(O'Malley et al., 2001, Robb et al., 2008, Hou, 2005b, Garcia et al., 2011, Jilcott Pitts et al., 2013, Greiner et al., 2005, Good et al., 2010, Ekberg et al., 2014, Francois et al., 2009, Green et al., 2008, Weitzman et al., 2001, Lasser et al., 2008a, Garcia-Dominic et al., 2012, Fernandez et al., 2008, Ward et al., 2011, Brouse et al., 2003)

	Lack of family history	Lack of family history of colorectal screening	(Wackerbarth et al., 2008, Beyer et al., 2011, Foo et al., 2011)
	Previous experience	Previous negative experience	(Wackerbarth et al., 2008, Jones et al., 2010, James et al., 2011)
	Lack of self-efficacy	Lack of belief in one's ability to do the screening successfully (to use the test)	(Brouse et al., 2003, Aubin-Auger et al., 2011, Javanparast et al., 2010, Javanparast et al., 2012)

1. Facilitators

0.0. Awareness

Awareness of colorectal cancer symptoms, screening for it, and the screening purpose has been one of the highly reported determinants of screening for colorectal cancer (Javanparast et al., 2012, Severino et al., 2009, Molina-Barcelo et al., 2011, Beeker et al., 2000, Holmes-Rovner et al., 2002, O'Sullivan and Orbell, 2004, Palmer et al., 2008, Ruffin et al., 2009). To be exact, according to the literature, people who are aware of colorectal cancer symptoms (as indications for screening), its time and regularity (Ruffin et al., 2009, Shokar et al., 2005, Wackerbarth et al., 2005, Winterich et al., 2011), different screening modalities (i.e. methods of screening e.g. FOBT) (Holmes-Rovner et al., 2002, O'Sullivan and Orbell, 2004, Palmer et al., 2008), and screening purpose are more likely to support and take part in screening programmes. For example, in two separate studies Palmer and colleagues and Beeker and colleagues showed that people who were aware of the purpose of screening (to detect the cancer in its earliest

stages of development) and the better treatment options that it provides were more likely to get screened (Palmer et al., 2008, Beeker et al., 2000). While the source of information and awareness about colorectal screening was not clearly stated in many of the studies, some studies reported that people's close social networks (families, friends, and partners) were the main source of information and awareness about screening (Beeker et al., 2000, O'Sullivan and Orbell, 2004, Palmer et al., 2008, Ruffin et al., 2009, Wackerbarth et al., 2005, Winterich et al., 2011, Goldman et al., 2009, O'Malley et al., 2004, Sly et al., 2013, Oster et al., 2013, Ekberg et al., 2014, Hoffman-Goetz et al., 2008, Robb et al., 2008, Palmer et al., 2014). Moreover, public education about colorectal cancer was raised as the main source of awareness about colorectal cancer in some studies. According to these studies, public educational measures raised people's awareness of colorectal cancer, its symptoms, screening options, and the need for screening when asymptomatic. As a result, it eased excessive irrational fear about this cancer (Greiner et al., 2005, Severino et al., 2009, Aubin-Auger et al., 2011, Ruffin et al., 2009, Beeker et al., 2000, Holt et al., 2009, Tarasenko et al., 2011). Totally speaking, such educational measures increased the publicity of colorectal cancer and made it more socially acceptable to talk about previously-thought taboo issues such as rectum, faeces, cancer, and screening in the public. Interestingly, there are also some reports of disparity in the awareness of screening purposes and procedures, with people of higher socioeconomic groups and women being more informed than other groups (Holmes-Rovner et al., 2002).

0.1. Perceived risk

Although it can be argued that risk perception is in close relationship with screening knowledge, they are reported as two separate determinants of screening in the literature. According to the reviewed literature, those who have a higher perception of colorectal cancer risk are more likely to get screened (Palmer et al., 2008, Rees et al., 2008, Kiviniemi et al., 2011). For instance, in a systematic review conducted by Kiviniemi and colleagues, it was

revealed that there was a strong relationship between the likelihood of screening and risk perception (Kiviniemi et al., 2011). Oster et al. also showed that those who perceived that they are at a higher risk of colorectal cancer (because of age, family history, personal history etc.) were less ambivalent about screening and had a higher chance of adopting screening behaviour (Oster et al., 2013).

0.2.Positive attitude towards test

Several studies have shown that the attitude of people towards colorectal cancer screening tests, mainly FOBT, can play an important role in the decision to be screened (Molina-Barcelo et al., 2011, Aubin-Auger et al., 2011, Ruffin et al., 2009, Beeker et al., 2000, Holmes-Rovner et al., 2002, O'Sullivan and Orbell, 2004, Shokar et al., 2005, Greisinger et al., 2006). For example, some studies have shown that FOBT was perceived as a convenient, screener-friendly, painless, home-based test among the participants and that this had a positive effect on their decision for screening by FOBT (Goel et al., 2004). Other studies have, in contrast, reported a preference of other screening modalities over FOBT; for example, some studies have reported that participants prefer colonoscopy as they see it more complete and precise (Greisinger et al., 2006).

Motivation

Motivation for screening was another factor referred to as a facilitator of screening in the literature. There were several sources for screening motivation in the reviewed literature, as follows: (1) peace of mind provided by screening that someone does not have colorectal cancer (Severino et al., 2009, Bass et al., 2011, Palmer et al., 2008, Varela et al., 2010, Oscar, 2009, Jilcott Pitts et al., 2013, Clavarino et al., 2004, Gwede et al., 2011, Robb et al., 2008); (2) being pro-active and health conscious to stay cancer-free and live longer (Tarasenko and Schoenberg, 2011, Frew et al., 2005, Weitzman et al., 2001); (3) partner (spouse) as a motivator (especially

women) (Molina-Barcelo et al., 2011, Beeker et al., 2000, Holmes-Rovner et al., 2002, Ekberg et al., 2014, Lobchuk et al., 2012, Manne et al., 2012, Goodman et al., 2006, Holt et al., 2009, Greiner et al., 2012); and (4) having a close person in the social circle (network) with colorectal cancer (died or survived) (Severino et al., 2009, Molina-Barcelo et al., 2011, Oster et al., 2013, Oscar, 2009, Jilcott Pitts et al., 2013, Ekberg et al., 2014, Bong and McCool, 2011, Chapple et al., 2008, Lobchuk et al., 2012, Manne et al., 2012). In contrast to the last source of motivation for screening, some studies have, interestingly, shown that presence of a person with (a history of) colorectal cancer in one's social circle can be demotivating for some people, to the extent that they may see no advantage in screening (Brouse et al., 2004, Lobchuk et al., 2012). This matter will be discussed in the barriers section.

In one of the most interesting studies on partners' motivational effect on screening, Manne and colleagues tried to explore a partner's influence on screening decisions among couples in the USA. 18 couples aged 50 and over, with and without screening history, were interviewed about their methods of communication about colorectal cancer screening and the strategies they used to encourage their spouse to take-up screening. For example, couples were asked about their discussions about screening, barriers against such discussions, motivations to discuss, the ways they are able to talk and provide support, and whether the partner was helpful and in what ways. An interdependence model was used to guide the analyses. An interdependence model provides a framework about how couples' interdependence processes shape and change behaviour. The model has three constructs: the interdependence construct that points to influences that partners put on each other's motivations, preferences, behaviours, etc.; motivational transformation construct that points to changes in behaviour that emanate from not an individual motivation, but from the relational motivation; and correspondence construct that is the degree of agreement between partners about the outcome of behaviour change. These constructs were used as a template to guide the thematic analysis of interview transcripts. According to the

findings, there were two kinds of partner effects on screening behaviour of couples (direct and indirect). Direct effect happened when one partner was the proximal cause of screening behaviour of the other. This proximal cause of screening happened in three ways: partnership, leadership, and persuasion. Indirect effect happened when one spouse was providing and showing information, experience, or actions that encouraged screening in another spouse, even when there was no such a pre-considered aim of influence. Indirect effect happened mostly by companionship, support, and peer socialization (Manne et al., 2012). However, such studies are still lacking in the literature and more research is needed to better understand the spousal motivation effect on screening.

In another study on family and friends motivational effect on screening decision, Lobchuk and colleagues explored the role of family members in the promotion of screening for colorectal cancer in Manitoba, Canada. Researchers conducted semi-structured interviews with 27 participants and 19 of their family members and friends. The interviews were transcribed and analysed using content analysis and constant comparative techniques. A maximum variation sampling method was used in order to include patients from both genders and with different screening histories. Patients and family members believed that the family plays supportive roles in the promotion of bowel screening as follows. Family members act as a reminder of the test and help the patient to undertake it. Family plays an instrumental role so that the family members undertake some concrete activities (like doing the screening together) that enable the patient to adhere to the test. Family plays an emotional role so that the family members accompany the patient or listen to their emotional concerns when taking the test. Family members act as a good role model so that patients observe and learn and do the test. Participants also believed that some family factors facilitated the screening up-take. The relationship between the patient and family members was one of those factors. This factor pointed to the type of relational engagements between family members, and their caring and communication

patterns. Having an influential peer group was another screening facilitator that included people from the same age group as the participants who had had the same experience before and were influential in providing information, encouragement, and support for patients to take up the test. Intimate spousal knowledge about each other's health needs was another facilitator that participants believed had a very influential effect on screening behaviour. However, some hindering factors also prevented families from supporting the screening. For example, male family members did not have such an attentive and nurturing behaviour as female counterparts had in encouraging screening. Finally, perceiving bowel movements as a taboo topic to talk about within the family was another hindrance against family role in screening (Lobchuk et al., 2012).

Generally speaking, sources of motivation for screening can be categorized into two categories of intrinsic and extrinsic factors. Interestingly, most of studies and theories on screening behaviour (e.g. health belief model, reasoned action theory, planned behaviour theory, etc.) have so far focused on extrinsic sources of motivation for screening and intrinsic sources have drawn less attention in the studies (Patrick and Williams, 2012). Namely, the need for social relatedness, as one of the basic needs and intrinsic motivations for human beings, is one of the factors that we can find rare evidence for its importance in colorectal cancer screening studies (Patrick and Williams, 2012). Even the above-mentioned studies on effects of families/partners/peers on screening behaviour do search for extrinsic sources of motivation and the inherent psychological value and need of belonging to a group and its effects on screening behaviour has no place in those studies. Social relatedness refers to a sense of being connected to and accepted by others (Kim and Drumwright, 2016, Gilal et al., 2019). There is some evidence that this psychological need facilitates relationship building, community engagement, behaviour adoption, and internalization of other extrinsic sources of motivation (Connell and Wellborn, 1991, Deci and Ryan, 2000, Ryan and Deci, 2000, Kim and

Drumwright, 2016). Evidence also shows that when level of intrinsic motivation is low, presense of opportunities for social relatedness increases the level of that motivation (Anderson et al., 1976, Ryan and Grolnick, 1986, Kim and Drumwright, 2016). Considering the target group for colorectal cancer screening, people of over 60 years old, who are normally prone to loneliness and isolation, mainly because of their health status and needs, more research and attention is needed to better understand the effects of social relatedness on colorectal cancer screening behaviour in this group. More importantly, this understanding can help public health practitioners to devise interventions that can raise levels of intrinsic motivation for screening among these people. Interestingly, there has been an increasing focus and research on importance of social relatedness as a behavioural motivator in other scientific disciplines over the recent years (e.g. marketing)(Kim and Drumwright, 2016, Gilal et al., 2019, Hagger and Chatzisarantis, 2009) which can also be utilized is studies and interventions on colorectal cancer screening behaviour.

Physician role

A number of studies reviewed in this study showed that patients' communication with a physician and physician recommendation can have a very significant effect on encouraging people to get screened. In fact, talking with a physician and getting the information and support from them (especially about importance of screening when the person is asymptomatic) was one of the main reasons for decisions to take part in screening (Severino et al., 2009, Aubin-Auger et al., 2011, Bass et al., 2011, Holmes-Rovner et al., 2002, Palmer et al., 2008, Ruffin et al., 2009, Shokar et al., 2005, Garcia et al., 2011). However, studies have also shown that many physicians fail to give the required information and recommend the screening, acting as a barrier against screening. This matter will be discussed in the barriers section.

0.3. Family history

Family history was one of the most consistently reported facilitators of screening in the literature (Rees et al., 2008, Subramanian et al., 2004, Ruffin et al., 2009, Holden et al., 2010, Javanparast et al., 2010, Aubin-Auger et al., 2011, Beyer et al., 2011, Bong and McCool, 2011, Ait Ouakrim et al., 2013). For example, in a systematic review by Rees and colleagues, 30 papers published from 1994 until 2006 were critically selected from the literature to understand the patterns and determinants of screening participation among the people with a family history of colorectal cancer. According to their findings, rate of FOBT up-take ranged from 22 to 88% among people with a family history of colorectal cancer, showing a higher concentration of screening among people with a positive family history of colorectal cancer (Rees et al., 2008). In an interesting study on the role of ambivalence about screening, Oster et al. showed that those who perceived that they are at higher risk of colorectal cancer because of their family history had less ambivalence about screening (Oster et al., 2013).

0.4. Previous experience

Positive previous experience of colorectal screening was also a facilitator of screening in the reviewed literature (Chapple et al., 2008, Aubin-Auger et al., 2011, Garcia et al., 2011, Ekberg et al., 2014, Dharni et al., 2016). Interestingly, three studies in the UK that were similar to the present study, especially one in the Midlands undertaken by Ekberg and et al, all reported the previous experience of screening (even for other cancers) as one of the main facilitators of screening (Ekberg et al., 2014, Chapple et al., 2008, Dharni et al., 2017). The present study can be a test of the importance of previous experience of screening in Hull.

2. Barriers

2.1. Lack of awareness

Reviewed literature has shown that a considerable number of people around the world still have limited information and awareness about colorectal cancer, its symptoms, mortality, screening purposes, and different screening modalities. Specifically, many people have little knowledge about screening benefits, importance, periodicity, and its impact on mortality (Javanparast et al., 2012, Severino et al., 2009, Molina-Barcelo et al., 2011, Beyer et al., 2011, Aubin-Auger et al., 2011, Bass et al., 2011, Brouse et al., 2004). This lack of knowledge leads to people misunderstanding and underestimating the importance of screening. In fact, in most of the studies found that the main knowledge-related barrier for screening was a lack of adequate knowledge about screening purposes and the fact that screening is especially important when people are asymptomatic. Lack of public educational measures on colorectal cancer, compared to other common cancers, was raised as the reason for such a lack of knowledge and understanding (Bong and McCool, 2011, Beeker et al., 2000). For example, Beeker and colleagues reported of a culture of health in America in which colorectal cancer was a disease of low visibility that "no one wanted to talk about" and there was no proper picture or narrative of colorectal cancer and its screening. The researchers, accordingly, concluded that there should be public education campaigns, decision aids, and interventions to raise the level of screening awareness and its benefits (Beeker et al., 2000).

2.2. Perceived risk

Interestingly, research has shown that the presence of an optimistic bias for a lower chance of getting colorectal cancer can act as a barrier against getting screened (Severino et al., 2009, Ekberg et al., 2014). For example, in a study by Ekberg and et al. in the Midlands in the UK, a place close to Hull geographically, it was shown that a crooked perception as to the risk of

colorectal cancer acted as a main barrier against getting screened in that region (Ekberg et al., 2014). However, this matter is in need of more research in future, especially in terms of its relationship with socioeconomic status.

2.3. Negative views about cancer

Fear of cancer, screening results (that might be cancer), suffering from cancer (if diagnosed), and fatalistic views of cancer are reported, in the literature, as the main (negative) attitudinal factors preventing from colorectal cancer screening. For example, some studies reported the following (chunks of) quotes as examples of negative fear-based attitudes to colorectal cancer: "*no one is ready to talk about cancer"*, "*not knowing what happens in the body is better"*, "*death is better than knowing that you have cancer and then suffer from it"* (Severino et al., 2009, Molina-Barcelo et al., 2011, Beyer et al., 2011, Beeker et al., 2000, Holmes-Rovner et al., 2002, O'Sullivan and Orbell, 2004, Palmer et al., 2008, Goel et al., 2004). In a study in the UK, fear of cancer diagnosis was a major barrier against screening among White British people, regardless of their socioeconomic status (Dharni et al., 2017). Fatalism is the belief that death is pre-determined and that prevention (i.e. screening) does not work, as whatever is going to happen will happen regardless of someone's desire or action. Especially, in terms of cancer such an attitude holds that not only is death predetermined, but also cancer itself is so fatal that even screening cannot stop it. This negative attitudinal matter has been reported in many studies as well (Goodman et al., 2006, O'Malley et al., 2001, Lasser et al., 2008a, Lee and Lee, 2013). Some studies have also reported of unequal concentration of fatalistic views regarding screening among people of lower socioeconomic groups and men, suggesting that more research is required as to the reasons for such a phenomenon (O'Malley et al., 2004).

2.4. Negative attitudes toward FOBT

Another factor raised in the reviewed literature that acts against the decision to get screened is the negative attitude toward screening modalities, especially FOBT. This factor entails the following attitudinal categories: aversion towards the test, awkwardness of the test pack, and limited belief in efficacy of the test. Many studies have reported that people choose not to get screened as they don't see the FOBT as a desirable test for screening. In fact, aversion towards the test, as it involves dealing with body waste, becomes a challenge for people to overcome. That is why many people request cleaner, more hygienic and socially acceptable tests for screening. Moreover, the way the FOBT kit should be stored and handed back to the test centre is another issue. Many people have reported in the studies that, aside from the non-hygienic nature of the test, the way the test should be stored for several days and posted back to the test centres is a challenge itself and might be even considered as an act of social taboo in some societies (Javanparast et al., 2012, Beyer et al., 2011, Aubin-Auger et al., 2011, Beeker et al., 2000, Shokar et al., 2005, Winterich et al., 2011, Goel et al., 2004, Greisinger et al., 2006, Jones et al., 2010). More interestingly, alongside such aversive attitudes to the test, some studies have reported people's lack of belief in the efficacy of screening for colorectal cancer, in general, and FOBT, in specific. The main reason for that disbelief was being a witness to fast and dramatic growth of colorectal cancer among friends and relatives in a very short time span. Also, the fact that screening is not 100% accurate was disappointing for some people. These two matters made people question the efficacy of the test and acted as barriers against participation in screening (Javanparast et al., 2012, Aubin-Auger et al., 2011, Bass et al., 2011, Beeker et al., 2000, Frew et al., 2005, Hou, 2005, Foo et al., 2011).

2.5. Lack of motivation

Interestingly, having a person with an experience of grappling with colorectal cancer did not act as a motivator for all people all the time. In fact, there were numerous reports in the

literature pointing to the fact that such an experience was a dis-motivator for screening. Moreover, negative accounts of screening experience by people in someone's social circle was also a dis-motivator and dissuasive (Brouse et al., 2004, Beeker et al., 2000, Palmer et al., 2008, Jones et al., 2010, Lobchuk et al., 2012, Ogedegbe et al., 2005, Wackerbarth et al., 2008, Chapple et al., 2008). Another dis-motivator for screening reported in the reviewed literature was the presence of other life or health priorities that made screening less important (Molina-Barcelo et al., 2011, Aubin-Auger et al., 2011, O'Sullivan and Orbell, 2004, Palmer et al., 2008, Garcia et al., 2011). For example, some studies reported that people thought that their work commitments, family issues and commitments, and taking care of other people's needs were more important than their own screening (Beyer et al., 2011, Brouse et al., 2004, Palmer et al., 2008, Wackerbarth et al., 2005, Garcia et al., 2011)

2.6.Lack of physician role

Interestingly, some studies have reported that despite the importance of physicians' role in recommending the test and obviating patients' ambivalence about value of screening, many physicians fail to recommend the screening, something that is one of the main complaints of patients in terms of their reluctance for screening (Beyer et al., 2011, Coronado et al., 2006, Denberg et al., 2005, Oster et al., 2013, Ekberg et al., 2014, Lobchuk et al., 2012, Manne et al., 2012, Gwede et al., 2011, Green et al., 2008, Wackerbarth et al., 2008, Tarasenko et al., 2011, Good et al., 2010, Lasser et al., 2008b, Fyffe et al., 2008, Reeder, 2011, Aubin-Auger et al., 2011). More importantly, literature also showed that if there was a recommendation from physicians, but the provided information (about FOBT) by them was not appropriate and adequate, the chance of screening was low as well (Lasser et al., 2008b, van Dam et al., 2013).

2.7.Contextual factors

There are some contextual factors raised in the literature as barriers against colorectal cancer screening. Contextual factors refer to issues related to socioeconomic status, gender, cultural norms, and linguistic issues. Context is in fact (according to the complex realism approach) the milieu that sets the scene for the emergence of other factors (facilitators or barriers). For instance, research has shown that screening is not considered as a proper behavioural habit in some cultures and settings (Molina-Barcelo et al., 2011, Goodman et al., 2006, Francois et al., 2009). People of some cultures, especially Asian cultures, believe that their traditional cuisine can prevent cancer, so there is no need for screening (James, 2013, Francois et al., 2009, Robb et al., 2008). Interestingly, according to some research, women under-present in colorectal cancer screening programs as they think that colorectal cancer only happens among males (Beeker et al., 2000). However, it was shown in a systematic review that there is no difference between men and women in terms of the presence of screening barriers (Javanparast et al., 2010). There are also some barriers that emanate from the dis-favourability of socioeconomic conditions. For example, some studies have shown that people of lower socioeconomic status may not get screened as they are afraid that if cancer is diagnosed, the family will lose its income source. Therefore, they prefer to sacrifice and forget about their health (Beyer et al., 2011, Greisinger et al., 2006, Goodman et al., 2006). This matter is different from the case of some people who sacrifice their health because of their work or family commitments, covered in the lack of motivation factor, as such a matter is not necessarily due to economic factors. In an interesting systematic review that focused on the effects of area level socioeconomic status on screening behaviour, Pruitt and colleagues also reported of positive significant relationship between area level socioeconomic status and colorectal cancer screening in the literature (screening rates were higher in the better-off areas). Interestingly, the relationship between colorectal cancer and area level socioeconomic status was more consistent than the relationship

in other cancers (e.g. cervical and breast cancers) (Pruitt et al., 2009). Research has also shown the negative effects of a poor level of health literacy among people of lower socioeconomic status. These people have difficulty in understanding some medical terms like “rectum”, “colon”, “faecal”, etc., making it difficult for them to understand the information and follow the screening recommendations (Getrich et al., 2012, Bass et al., 2011, Beeker et al., 2000, Holt et al., 2009, Greisinger et al., 2006, Oster et al., 2013). Interestingly, a systematic review showed that there was a positive relationship between education levels and likelihood of screening (Javanparast et al., 2010, Aubin-Auger et al., 2011, Winterich et al., 2011), but there was no such a relationship between health literacy and informed decision making in another systematic review (van der Heide et al., 2015). One study in the UK showed that the struggle to understand the screening instructions was a notable barrier for all the participants from low levels of socioeconomic status, regardless of their ethnic status (Dharni et al., 2017). Language difficulties and differences are also raised as a barrier to screening among minorities in some literature. For example, research has shown that non-native English speakers find the FOBT instructions difficult and challenging to follow. Therefore, the chance of overlooking the screening increases as a result of misunderstanding (Javanparast et al., 2010, Severino et al., 2009, Coronado et al., 2006, O'Malley et al., 2001). Generally speaking, most of the reviewed literature has shown that screening barriers are more concentrated among people of disadvantaged conditions (Javanparast et al., 2010).

2.8. Lack of family history

Although with a low frequency of citation, lack of family history was also amongst barriers reported in the reviewed literature to act against screening (Wackerbarth et al., 2008, Beyer et al., 2011, Foo et al., 2011). In an interesting study, Garcia et al. showed that a lack of family history may lead to misunderstandings about screening that can prevent from screening (Garcia et al., 2011). This finding study is in line with Oster et al. study who showed that family history

decreases ambivalence about screening (Oster et al., 2013). However, there is a need for more research to clarify the role of the lack of family history on screening behaviour.

2.9. Previous screening

Some studies have reported that having a negative experience of screening can prevent future screening (Wackerbarth et al., 2008, Jones et al., 2010, James et al., 2011). For example, in a study by Wackerbarth and colleagues, one of the main themes reported by the participants was labelled as "Not again", pointing to negative previous experiences that were strong enough to prevent screening behaviour from happening (Wackerbarth et al., 2008). However, the number of studies reporting such a barrier is not high in the literature.

2.10. Lack of self-efficacy

Self-efficacy refers to a belief that a person is able to successfully administer a health behaviour (e.g. screening). Lack of self-efficacy has been also reported as one of the main obstacles for colorectal cancer screening in the literature (Brouse et al., 2004, Aubin-Auger et al., 2011, Javanparast et al., 2010, Javanparast et al., 2012). For example, in a systematic review by Javanparast and et al, lack of self-efficacy was reported as one of the main barriers against screening for colorectal cancer (Javanparast et al., 2010). More importantly, in another study by Javanparast and colleagues in Australia, it was shown that lack of self-efficacy was more concentrated among people of minority and lower socioeconomic status (Javanparast et al., 2010). However, as FOBT is a relatively easy-to-do test (but not user-friendly and hygienic necessarily), the number of studies that report self-efficacy problems for FOBT in the literature is lower, relatively speaking, than studies that report it for other screening modalities (e.g. colonoscopy).

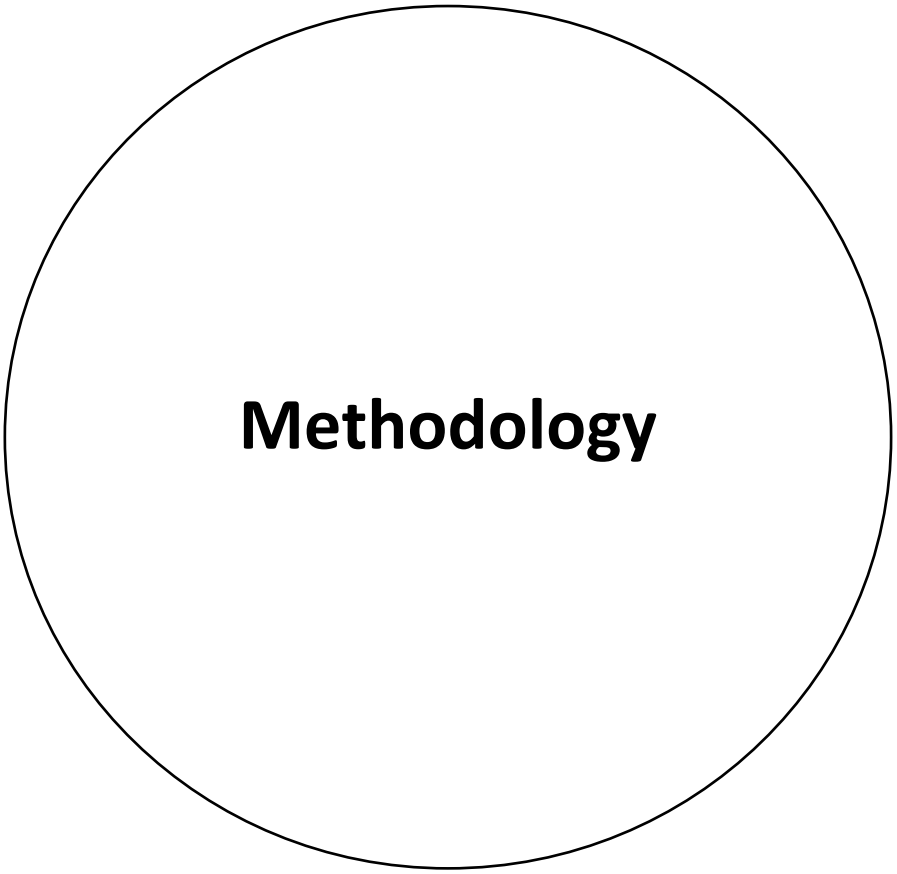
3. Overarching conclusion

Generally speaking, there has been a huge number of studies on the determinants of colorectal cancer screening so far (Cossu et al., 2018). For example, there has been a remarkable number of systematic reviews on each specific or even all the determinants of screening (Ait Ouakrim et al., 2013, Atkinson et al., 2015, Hewitson et al., 2008, Holden et al., 2010, Jepson et al., 2000, Oh and Jacobsen, 2014, Pruitt et al., 2009, Reynolds et al., 2013, Rogers et al., 2015, van der Heide et al., 2015, Wools et al., 2016, Wortley et al., 2014, Cossu et al., 2018). For instance, in one of the most comprehensive systematic reviews on colorectal cancer screening, covering all the studies published from early years of the 20th century onward, Honein-AbouHaidar and colleagues investigated colorectal cancer barriers and facilitators to screening (Honein-AbouHaidar et al., 2016). According to their review, awareness of colorectal cancer screening was the major factor influencing the decision to take part in screening. On the one hand, this awareness affected the views about and attitudes towards cancer (lack or presence of fear and fatalism), screening (lack or presence of test aversion), and the motivation to do the screening. On the other hand, the awareness itself was affected by public education, physician recommendation, and social networks. Moreover, language related barriers, logistic factors, and cultural beliefs were the major barriers against participation (Honein-AbouHaidar et al., 2016). However, despite such comprehensive systematic reviews and resultant knowledge of screening determinants, there are still some gaps in the knowledge that are worth mentioning (Cossu et al., 2018). First, some psychological issues related to screening are still in need of deeper understanding. Namely, the fear of cancer, its components, and effects on screening is poorly understood. For example, there is inconsistency in the effects of fear on colorectal cancer screening either as a facilitator, barrier, or even as a delayer. The reason why fear acts as a facilitator for some people while as a barrier for other people is not yet well understood. Moreover, fear of cancer seems to be a multi-dimensional construct with biological, cognitive,

affective, behavioural facets that need to be taken account of. The tools to examine and measure the fear of cancer are also less developed. These issues should be considered in future research on the psychological determinants of colorectal cancer screening (Cossu et al., 2018). Second, although existing inequalities in participation in colorectal cancer screening is a well-established fact, there is less knowledge about patterns of distribution of the determinants across social groups. For instance, there is a gap in the current knowledge in terms of distribution of the effects of social networks (spouse, family, and friends) on screening across the socioeconomic groups (i.e. whether there is any difference between people across the socioeconomic spectrum in terms of the network effect). This also applies to other factors like fear, self-efficacy, previous experience, negative attitudes to test, family history etc. Third, although studies have effectively revealed the complexity of screening behaviour, most of them have failed to represent the complexity of behaviour in a meaningful and illuminating way. In fact, one can, with some certainty, state that except for some studies (Wackerbarth et al., 2008), almost all studies have only listed the conditions that were revealed to be of importance. In fact, these studies did not reveal how these conditions can sit together and shape the screening behaviour, as if there is a total mess out there and no path or configuration can be depicted. Weitzman and colleagues have expressed this problem in a very informative way. They have postulated that current studies fail to see the determinants as they are, i.e. multidimensional, complex, and interconnected, and this may explain why only the presence of good knowledge and beliefs cannot predict CRC screening behaviour (Weitzman et al., 2001), the way these studies expect them to do. For instance, even one of the most comprehensive reviews taken so far came up with a conceptual model that has a "one-size-fits-all" approach and, implicitly, purports that there is only one way to have the screening behaviour observed out there in society (Honein-AbouHaidar et al., 2016). Fourth, the same problem of uni-dimensionality and de-contextualization applies to the studies on inequalities in screening as well. In fact, except for

few studies (Raine et al., 2016a), the mechanisms behind inequalities are not investigated in the literature. The subject of what factors come together to create pathways or processes through which the unequal adoption of screening behaviour emerges in each social context is not given due attention in the literature.

Against a backdrop of such shortcomings in understanding screening for colorectal cancer and its inequalities, this study aimed to use a complexity and configurational-informed approach to reveal the configurations through which screening behaviour (or lack of it) takes place in two neighbourhoods in Hull. The next chapter will present the methodology that was used to reveal such complex screening configurations.


Methodology

1. Philosophical background

Every research project is in need of a clear and articulate philosophical stance to be credible throughout the research enterprise. The philosophical stance that this study is mounted on is complex realism, informed by a new branch of science called complex systems science.

1.1. Complex systems

There are various definitions for systems(Byrne, 2009). To be more specific, a system can be defined as a set of interconnected and interacting components. Generally speaking, there are two kinds of systems: simple and complex systems. A complex system is one in which the whole is greater than the sum of its components (emergence) and where the system has some properties that cannot be understood solely in terms of constituent components. Most social science branches, including public health, have resorted to simple systems ideas to understand social issues so far (Byrne, 2009). These ideas are in fact the principles of the dominant mechanistic science. Such a science is based on the following five principles:

1) Exogenous variables/forces should be either controlled or analytically excluded from the causal configurations;
2) The researcher/scientist should know of the universal laws that govern the system;
3) It is possible to precisely predict the future state of the system and test it empirically;
4) The explanation provided for the system holds true if and only if the causal forces/components do not significantly and dynamically interact with each other.
5) The systems are linear, i.e. the system's dynamics can be causally shown by a simple sum-up of the independent forces/variables running the system. That is why these systems are said to be equal to the sum of their constituent forces (Byrne and Callaghan, 2013).

According to Rosen: a “simple system is one to which a notion of state can be assigned once and for all, or more generally, one in which Aristotelian causal categories can be independently segregated from one another. Any system for which such a description cannot be provided can be called complex. Thus, in a complex system, the causal categories become intertwined in such a way that no dualistic language of state plus dynamic laws can completely describe it. Complex systems must then process mathematical images different from, and irreducible to, the generalized systems which have been considered universal” (Rosen, 1987).

Complex systems science is a framework of understanding which adopts the ontological stance that the world (natural and social) is made up of complex systems, and if we are to fathom it, we have to understand it in this way. Complex systems possess the following features (Byrne and Callaghan, 2013, Byrne and Ragin, 2009):

1- Non-linearity: complex systems are non-linear, i.e. unlike simple systems, there is no proportionate relationship between changes in components of the system and the change in system state or outcome. This non-linearity makes complex systems hard to predict.
2- Emergence: Non-linearity produces a quality in complex systems called emerging property. Non-linearity comes from complex cooperation/interaction between components. However, such complex and non-linear interactions lead to the production of higher level outcomes or qualities (like structures, events, or behaviours) in a system where the properties can be quite different from the components. After these properties emerge at higher levels they feed back and interact with the components and their interactions. One important implication of non-linearity and emergence is that complex systems cannot be analysed and integrated, in reality and mathematically, the way simple ones can be. Another implication is that as each system has its unique emerging

properties, the extraction of nomothetic laws to be applied for other complex systems becomes very difficult.

3- Far from equilibrium: complex systems are not like systems in equilibrium in which any change in components or in the environment is met by negative feedback that keeps the system in its previous place. Nor they are like chaotic systems where a very small change in a component causes the system to undergo a radical transformation. Complex systems are normally close to equilibrium systems, i.e. they are always changing but within a limited range. In fact, alongside negative feedback that does retain the system in its current state, there is positive feedback within the system that pushes it away from that state. The balance and dynamics between the negative and positive feedback loops make the system change its state across time and place. In fact, their trajectory falls into a torus basin of attractors; they do change but not fundamentally and qualitatively. However, these systems have this potential to change qualitatively and fundamentally and become far from equilibrium systems. In fact, the most significant feature of complex systems is their capacity to evolve; not only can these systems undergo material and structural changes, they can also experience qualitative transformations in their evolutionary path of transition across time and space and can become a completely new system.

4- State space and attractors: Two key terms in complex systems science are ‘trajectory’ and ‘attractor’. A trajectory is the path that a system follows through time. Mathematically, the trajectory can be defined as co-ordinates of a system at different times in a multi-dimensional state-space. The dimensions of the state space are variate measures that describe the system. An attractor is a point within the state space that a system is disposed towards. The attractor can be a torus (doughnut) attractor that can be found in close to equilibrium systems. It can be a butterfly attractor with two stable

states that can migrate from one to another. They can also be strange attractors which can be found in chaotic systems. Interestingly, one can think of attractors not in terms of a single system, but for a group of systems across their evolution. In this way, one can classify the systems and compare them as the attractors represent the system states; they are a qualitative thing that a system can belong to. Here, then, the question to ask would be what (generative) causal mechanisms have brought the systems to these attractors and what are the similarities and differences between those systems? This can therefore open a door for comparative methodologies.

5- Boundaries and hierarchies: Complex systems are configured of stratified elements. These elements reciprocally reinforce each other's effects and make up a coherent configuration. Systems have boundaries that separate them from their environment. However, boundaries are not closures, as complex systems are open and in constant exchange of matter, energy, and information with their environment. In fact, boundaries of complex systems are constitutive of the system; they connect the system with their environment and shape the system in this way. Sometimes boundaries can be functional, behavioural, and communicational. Moreover, systems are structurally hierarchical, i.e. there are layers within the systems that structure the system. Each layer is an entity made up of its own components and qualities. The lower levels generate the higher levels and there are dialectical relationships between levels. In referring to these hierarchies some scientists talk of sub-systems that are nested within each other, for example we can start from lower levels and go up to higher levels. However, it is completely possible in social systems to have no such well-structured systems. In fact, hierarchies normally do interpenetrate each other and there are relationships that cut across hierarchies. That is why some scientists call social systems "assemblages" since

the separation of one member from a hierarchy (migration of a family member) should not be a threat to a system's integrity.

6- Control parameters: control parameters are the elements in a complex system that if they change, the nature of the system can change qualitatively so that the system will move towards a new attractor in the state-space. Control parameters are of remarkable importance as they can refer to parameters that should be changed if one is to guide the system in a positive manner. However, usually a combination of parameters (higher order parameters) and not one parameter (first order) necessarily has the power to determine the state (outcome) of the system.

1.2. Complex realism

Informed by the above descriptions of the qualities of complex systems, pillars of a complex realist outlook on the social world will now be presented (Byrne and Ragin, 2009, Byrne and Callaghan, 2013, Byrne, 2009). Five principles of complex realism can be described as follows (Byrne, 2009):

1) Complex realism theorists hold that if science, social or natural, is to become a coherent attempt, scientists have to necessarily assume an objective reality (complex systems) independent of experience, some parts of which can be explained and manipulated and some parts not;
2) Complex realism theorists take the world as ontologically stratified and hierarchical. Therefore, the objects of science (natural objects or social products) are complex systems that are ontologically layered and hierarchically nested. These systems are openly structured, evolving, and loosely integrated.

3) Complex realism theorists assume the probability of a science of society/social entities in which complex social systems are assemblages of hierarchical entities making a coherent whole.
4) Complex realism theorists hold that the outcomes in open systems are *approximately* predictable. In fact, because of the layered ontology, causal processes in open systems are contingent structurally and delayed temporally. Therefore, causal laws in complex systems are tendential and normic. Moreover, causality in complex systems is complex, i.e. there are multiple factors that participate in causality, and, more importantly, there is more than one configuration of factors that can lead to an outcome.
5) A boundary of a complex system is concomitantly a function of the measures of the system itself and a product of the person describing it. In other words, a researcher frames the system in a certain way by their description (for a certain purpose), but they cannot frame it freely; the system itself constraints the frame. Therefore, epistemologically speaking, science is a social construct that is informed by reality.

To better outline complex realism, causal mechanisms in complex systems can be thought of as higher-order control parameters, parameters that act as potential causal forces for complex systems (Byrne and Callaghan, 2013). The take of complex realists on causality (in complex systems) can be simply formulated as:

Mechanism & Context => Outcome

In other words, generative mechanisms interact (&) with context and generate the outcome. According to complex realism, causality in complex systems is always contingent, complex, and multiple. 'Contingent' means that causality is local and dependent on the environment/context in which the system resides. 'Complex' means that causality is rarely a consequence of one single cause, but rather a consequence of multiple interactive factors. 'Multiple' means that one outcome (in complexity theory terms, the attractor state) may be

generated by various causal combinations. To be precise, there is more than one way by which a system state can emerge. This theory is against current linear modelling in which only one model is fit (imposed) to represent the data/outcome. More importantly, a fundamental element of causation in complex systems is the context. In fact, one can think of generative mechanisms as embodied complex causes where the mechanisms are always context-driven and contingent. Because of this context, the accounts of causation shall never be of a universal one, nor are they ideographic descriptions of single systems. Accounts can be well generalizable if, and only if, one can manage to systematically compare multiple cases of complex systems, but the generalization is restricted by the inherent situated complexity of cases and should be clearly specified by the researchers. This matter opens the way for a deeper exploration into the relationship between case studies in social science and complex systems science/complex realism (Byrne and Callaghan, 2013, Byrne and Ragin, 2009, Byrne, 2009).

2. Casing and complex systems

According to Ragin and Becker case studies is social sciences, in order to fully enjoy its merits, should change their attention from ontological issues (a universal and coherent definition of cases) to practical concerns (when, why, and how social scientists opt for cases) (Ragin and Becker, 1992). In this approach, casing is what all social scientists routinely do. Researchers try to ‘case’ their evidence to approach challenging issues by conceptualization, research design, and analysis. In fact, as complexity, specificity, and contextuality of empirical evidence are immense, a casing process turns one’s attention to some specific dimensions of that immensity, identifying some dimensions as relevant and leaving the rest as irrelevant for the time being. Different casing, therefore, would lead to differences in outlook, findings, and relations with reality, theory, and literature. As a result, the casing process can be an iterative enterprise. Moreover, the process of casing should produce cases that are similar enough and

separate enough so that they are comparable instances of the phenomenon of interest (Byrne and Ragin, 2009).

2.1. Casing and the complex realist perspective

The casing idea is very much in line with the complex realist paradigm in several ways. First, according to complex realism, the concept of case should be always in the foreground; i.e. cases are not mere observations but real entities that represent generative causal mechanisms playing a role in the background. Even though these entities and mechanisms are overcast by researchers' conceptualization of them, they still help in casing. Second, complex realism is very much in accord with the idea that casing is provisional and iterative. In fact, the casing process is always an open project for revision, from the start to the end of a study. Third, complex realism holds that social phenomena are complex, historical, contingent, and contextual. Through casing, researchers try to catch a glimpse of order in complex social phenomena to make it understandable temporally and contextually (Byrne and Ragin, 2009, Ragin and Becker, 1992, Zschoch, 2011)

But the reason why complex realism sees casing as fluid and tentative can be due to its view that cases are complex systems and not simple ones. Simple systems are linear, i.e. systems behaviour can be understood by summation of the effects of causal factors in the system. On the contrary, complex systems are internally constructed of interrelated configurations of factors/entities that can be perceived only in these terms, as mutually reciprocal influences that shape the whole system together. Moreover, complex systems have historicity and are prone to qualitative changes (phase-shift) that occur due to the interconnectedness and reciprocal effects of the system's constituents. These issues all have significant implications for casing, as the casing process should consider the interrelatedness of the phenomenon constituents, the boundary that should be drawn around the cases that may change from one casing process to

another one, and possible qualitative transformations. Furthermore, complex realism prevents the over-equalization and homogenization of social cases, so their specificity, complexity, and integrity are not lost (Byrne and Callaghan, 2013, Reed and Harvey, 1992, Byrne and Ragin, 2009).

Considering these similarities between casing and complex realism, some social scientists have proposed that social cases can be considered as complex systems. Abbot, for instance, has defined social cases as "fuzzy realities with autonomously defined complex properties" (Abbott, 1992). This definition is in fact a complex realist view of cases: they are out there prior to our definition, they are autonomous and they are complex. David Byrne emphasizes that (social) cases are empirically founded and socially constructed entities that human beings interact with at different levels in society (from the micro/individual level to the macro/state level) that inherently possess properties of complex systems (Byrne, 2009). In fact, informed by complex realism, some of the proposed definitions of ***cases as complex systems*** are as follows:

- *A case is a bounded system* (Stake, 1995).
- *"The move from population/analytic approach to case/narrative approach is thus a move to a new way of regarding cases – as fuzzy realities with autonomously defined complex properties …"* (Abbott, 1992).
- … "*cases – meaningful but complex configurations of events and structures – singular whole entities purposefully selected … not homogeneous observations drawn at random from a pool of equally plausible selections*" (Ragin, 2004).
- *"… cases are viewed as configurations – as combinations of characteristics. Comparison in the qualitative tradition thus involves comparing configurations. This*

holism contradicts the radically analytic approach of most quantitative work" (Ragin, 1994).

Interestingly enough, Ragin has defined (social) cases as configurations or assemblages. This definition is of great use conceptually and methodologically; namely, higher-order control parameters in complex systems are in fact configurations of parameters that are able to push the systems to change their states/attractors. So according to Ragin, cases, as complex systems, are constituted of configurations of parameters that have varying powers of influence on system states. The resonance of such a configurational understanding of cases, of complex and multiple causality, and of complex systems is enormous. We can treat real cases as configurational complex systems and do so at every level of case from the macro (societal) level to the micro (individual) level (Byrne and Ragin, 2009).

2.2. Configurational study of cases

The ramification of a configurational approach for social case research is that in case studies research should try to reveal the structure of configurations and their potential to produce a qualitative state in the system. The process of identification of the configurations is incomplete, temporal and local, as cases are complex systems. This process is exactly what case studies try to do to establish causality. Turning to the ideas in complexity theory, one can see cases in terms of their co-ordinates in a multidimensional state-space. While cases tend to have varying trajectories, they tend to cluster in specific locations (attractors) in a multidimensional state-space. Cases can qualitatively change, i.e. they can move from one location to another. However, most of the locations in the state-space are empty and only a limited number of locations are well populated by cases. The reason for such a distribution of cases across state-space is the way cases aspects/components fit and configure together. To be precise, aspects of cases come together in meaningful assemblages that have a syndrome-like character. These

"assemblages" show the interrelatedness of case aspects and the fact that just a few combinations of aspects can configure and cohere together well and produce something at a system level (Byrne and Ragin, 2009, Byrne and Callaghan, 2013).

3. Qualitative Comparative Analysis (QCA)

Having a configurational approach to social studies in mind, Charles Ragin, an American sociologist, developed a technique called Qualitative Comparative Analysis (QCA) to be of help in the comparative and interpretative analysis of multiple cases (Ragin, 1994). QCA aims to meet two opposing objectives: "capturing the complexity of cases" and "making some levels of generalization". To be precise, Ragin's aim was to synthesize a method that brings qualitative case-oriented and quantitative variable-oriented research together (Ragin, 2000, Byrne and Ragin, 2009, Ragin, 1994, Rihoux and Ragin, 2008, Zschoch, 2011, Schneider and Wagemann, 2012). QCA encompasses some important strengths of case-oriented research. For example, it sees cases as complex systems that should be understood in those terms and as a whole. More importantly, QCA has a view of causality that allows for complexity. QCA's tribute to complexity is multiple conjectural causation. This implies that (1) most of the time it is the combination/configuration of conditions that leads to the emergence of an outcome; (2) different combinations of conditions might lead to the same outcome; (3) because of the context, a condition of interest may have varying effects on the emergence of an outcome. So, outcomes emerge from different causal paths. Therefore, when using QCA, researchers do not impose one, and only one, model on the data (and vice versa), but instead they must reveal different causal configurations among the cases being studied. On the other hand, QCA has some features of quantitative-analytic research. For example, it allows for the analysis of more than a couple of cases, which can rarely be found in conventional case studies. This may lead to the possibility of some kinds of generalization. More importantly, QCA relies on Boolean algebra, in which one case can be reduced to certain conditions and outcomes. This is a kind

of analytic approach which opens the door to the possibility of replication. This gives other researchers the opportunity to verify and falsify the results. However, QCA is not a pure analytic approach as it opens the door to complexity and the holistic dimension of cases. Eventually, QCA allows researchers to reveal causal configurations and regularities that are parsimonious. 'Parsimonious' indicates that only a limited number of conditions and their configurations, from the total set of conditions and their configurations, are chosen as causal configurations (Rihoux and Ragin, 2008, Schneider and Wagemann, 2012).

In terms of techniques, QCA is an umbrella label that captures a whole group of methods. QCA using conventional Boolean sets (i.e. conditions can be coded only '0' or '1', and thus have to be dichotomized) was developed first, which is why the label 'QCA' has been often used to refer to this first technique. However, the standard practice is now to distinguish between 3 labels: (1) when referring explicitly to the original Boolean version of QCA, one can use csQCA (where 'cs' stands for 'crisp set'); (2) when referring to the version that allows multiple-category conditions, one can use mvQCA (where 'mv' stands for 'multi-value'); and (3) when referring to the fuzzy-set version, one can use fsQCA (where 'fs' stands for 'fuzzy set') (Rihoux and Ragin, 2008, Schneider and Wagemann, 2012).

3.1. Crisp-set Qualitative Comparative Analysis (csQCA)

Crisp-set QCA is the most widely used QCA technique. Crisp-set QCA was developed originally for the analysis of configurations of crisp-set memberships (i.e., conventional Boolean sets) (Schneider and Wagemann, 2012). With crisp sets, each case is assigned one of two possible membership scores in each set included in a study: "1" (membership in the set) or "0" (non-membership in the set). In other words, an object or element (e.g., a country) within a domain (e.g., members of the United Nations) is either in or out of the various sets within this domain (e.g., membership of the UN Security Council). Crisp sets establish distinctions among

cases that are wholly qualitative in nature (e.g., membership versus non-membership of the UN Security Council).

Below, the main operations of csQCA are briefly presented. This sequence is similar for the four techniques. However, as our outcome of interest was screening for colorectal cancer and it is a binary outcome (either screening occurs or it doesn't), csQCA was chosen as the method of analysing the data.

QCA starts by assuming causal complexity and then goes to capture that complexity. The researcher must first produce a data table in which each case displays a specific combination of conditions (with 0 or 1 values) and an outcome (with 0 or 1 values). Then, a truth table is formed which displays the data as a list of configurations. A configuration is a given combination of some conditions and an outcome. A specific configuration may correspond to several observed cases. The key step of the analysis is a Boolean minimization that reduces the long Boolean expression to the shortest possible expression (minimal formula) that unveils the regularities in the data. It is then up to the researcher to interpret this minimal formula, possibly in terms of causality (Schneider and Wagemann, 2012).

The variates/conditions that QCA uses as the basis of its comparative method are a mixture of descriptions of the internal characteristics of the cases and of the environment within which they are located. QCA never seeks to decompose the causal configurations and thereby to assign proportionate causality to any of the variates in a specific configuration. It has no similarity with a partial correlation coefficient. For QCA, causation is the result of the whole configuration. Although this is not the way QCA researchers usually express their understanding, one can see configurational causation as representing the complex product of the components of a complex system, the complex system itself, components of the environment of the complex system, and the environment. Moreover, the set of cases that

correspond to a particular configuration can be understood, in complexity terms, as the ensemble of cases with trajectories that have located them in a particular attractor in the state-space (Schneider and Wagemann, 2012, Rihoux and Ragin, 2008).

Some first micro-level applications of QCA have recently been conducted, with individuals as the units of analysis (Schneider and Wagemann, 2012). Micro-level cases, namely individuals who possess a certain set of characteristics relevant for a given research, provide an extensive amount of primary information, gathered through multiple sources, both qualitative and quantitative. The data on such micro-level cases (i.e. individuals) can be gathered through direct ethnographic interaction with each specific case. Further, in-depth interviews can be another valuable source of data about cases as well. Through this direct and intensive interaction with individual cases, a researcher is able to acquire in-depth knowledge about each case. This 'close' case knowledge about each case enables the researcher to make interpretations from a privileged stance in comparison to most macro-and meso-level QCA applications. However, researchers with a qualitative background who focus on individuals as cases might doubt the usefulness of QCA, as there is already a broad range of qualitative methods to analyse individuals. The point is that qualitative (e.g. ethnographic) approaches, which are often most appropriate for the study of individuals, can be supplemented by (or substituted with) QCA for two main reasons. On the one hand, QCA can be used to achieve a systematic comparison across a smaller number of individual cases (e.g. a sample between 10 and 30 cases) in order to preserve the complexity, whilst being as parsimonious as possible and illuminating otherwise often hidden causal paths on a micro level. On the other hand, QCA can complement qualitative interpretive analysis, by offering a certain degree of 'reduction' of rich qualitative data. With QCA, cases can be systematically compared only through a small number of variables (conditions and outcome). The final interpretation can then be a combination of narrative-like interpretive accounts supplemented by a few causal models that were discovered

(via QCA) among comparable individual cases, the strategy that the researcher adopts in this thesis (Schneider and Wagemann, 2012, Rihoux and Ragin, 2008, Ragin, 2014).

One question that might appear now is how case-oriented discussions translate into QCA techniques and their usage. As cases are inherently complex and as a key aim of QCA technique is to reduce this complexity and reach some level of parsimony, one may take this complexity-parsimony continuum as a guidance trail for reflection. If we look at the whole process of QCA, as a first approximation, we can represent this process as a 'funnel of complexity' (Figure 3). Indeed, there are three main phases in a QCA procedure, and each one of these corresponds to some evolution along the complexity-parsimony continuum. In the first phase (case selection and case description), the complexity is maximal as the user must, for each case, produce a case description (or case report). By definition, this case description contains (or should contain) at least some 'thick', historical information on the case, also relating to some of its specificities (cultural, etc.). However, by producing standardized case descriptions, and thus by entering a comparative template, one already diminishes the level of complexity and the researcher begins to synthetize the 'thick' case information. In the second phase, through the various technical steps of QCA proper – the 'analytic moment' – the researcher further diminishes the level of complexity. This happens by selecting conditions (variables), summarizing the information in numerical scores, and then performing all the steps to obtain minimal formulae (solution). At each one of these steps, one gains further parsimony. The maximal level of parsimony is therefore obtained at the end of the analytic, computer-aided part of QCA. Finally, in the third phase, the different 'causal paths' obtained through the minimal formulae are interpreted, which necessitates a 'return to the cases' and to their narratives and thus a move back to more complexity again (Byrne and Ragin, 2009, Rihoux and Ragin, 2008).

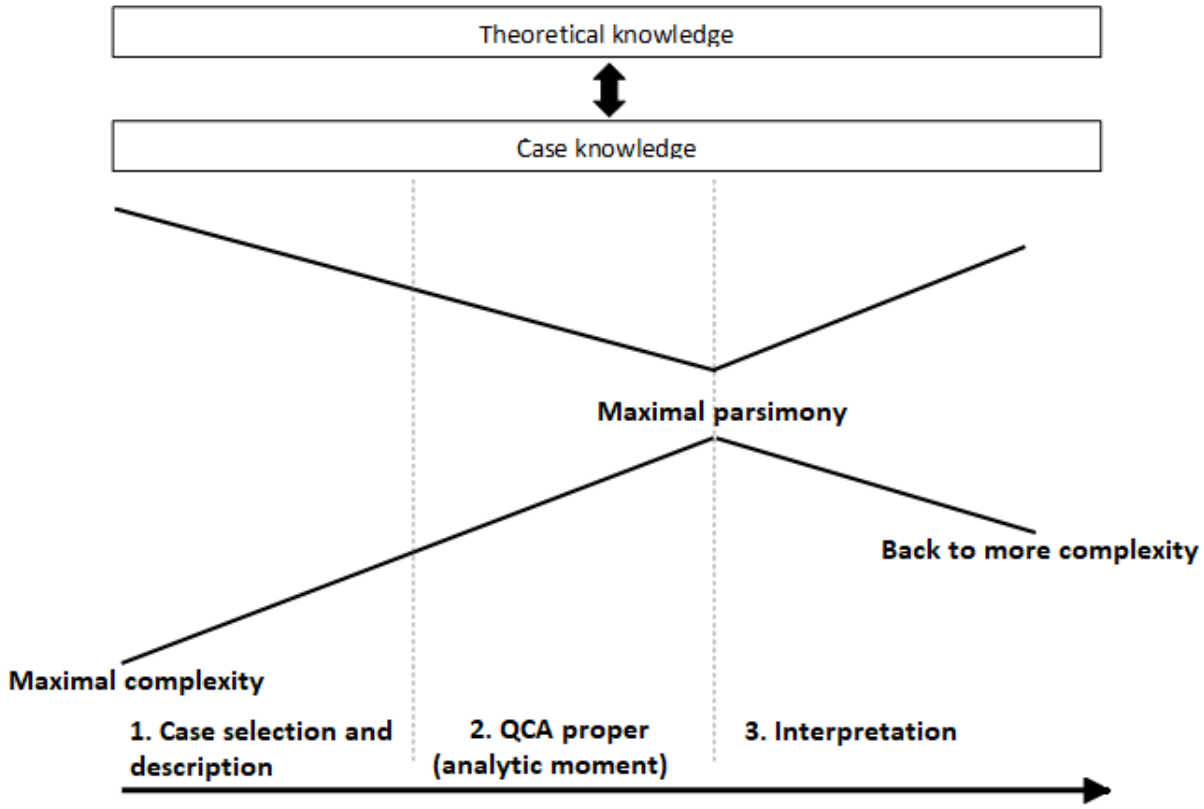


Figure 3. Funnel of complexity in QCA

Considering the process of analysis in QCA and looking at its multi-recursive dialogue with each case, we can clearly see that the whole process is actually a relative combination of qualitative and quantitative data on the cases. Each step will be elaborated upon more in the next sections. A text book written by Schneider and Wagemann on QCA and its set-theoretic foundations was used as the main reference book to write the following sections of this chapter, that provide technical details about methodological and practical processes of a qualitative comparative analysis (Schneider and Wagemann, 2012).

3. 1. 1 Before the 'analytic moment'

This step is made up of the following four operations: (1) comparative research design and case selection; (2) gaining case knowledge; (3) definition of the outcome of interest; (4) and model specification (selection of conditions). Selection of the cases, i.e. casing, in QCA is purposeful

and happens according to the variation of cases in some aspects (conditions and outcome) important for the analysis. This matter then makes having some 'thick' case knowledge a necessity. Various data collection strategies are normally used to gain the needed knowledge about cases. Participant observation, in-depth interviews, and focus groups are some of the methods to gain knowledge about cases in micro-level QCA. Semi-structured in-depth interviews will be used in the present study to gain knowledge about the determinants of screening behaviour. Model selection depends on the purpose behind the use of QCA. If it is used for theory testing, for example, the theory will then be acting as a guide in the selection of the conditions in the model. On the contrary, if QCA is used for exploratory purposes or theory building, then cases will inform the model's ingredients. Sometimes it can also be used to serve both purposes, starting from a theory or a model as a guide into a context and then using case knowledge to come up with new theories or models about an issue. The present study follows the last strategy of model selection. It starts with a model (developed by Honein et al. in 2016 as a guide to delve into the context and gain case knowledge and then comes up with a new model of screening (Honein-AbouHaidar et al., 2016).

3. 1. 2 The analytic moment: synthesis and minimization

This second main phase corresponds to the computer-aid part and is composed of the following four steps: (1) threshold-setting; (2) truth-table exploration and contradiction solving; (3) minimization process and logical remainders; (4) and resolution of 'contradictory simplifying assumptions'. By 'threshold' it means that the researcher should categorize the outcome and conditions into two categories of present and absent. Case knowledge is normally used for such a categorization. This process is also called 'calibration' by some scientists. In the current project, the researcher used deep case knowledge to calibrate the cases in terms of the presence or absence of the conditions and the outcome. Usage of a truth table is one of the main strengths of QCA. It is useful to examine the table before going for the main analytical process in QCA.

This examination can be useful in two ways: (1) it is informative to examine how the cases are clustered in configurations, as the cases which sit in the same configuration are logically equivalent in QCA. (2) Contradictory configurations can be identified and resolved. Contradictory configurations are the configurations that are home to cases whose outcome status is present in some and absent in some other, while they are the same in terms of conditions. Normally, such contradictions can be resolved either by re-examination of cases through their thick narratives and data (to see whether these cases are really the same in terms of conditions and the outcome), or by addition of some new factors (conditions) that were overlooked to be entered into the model in the first steps. Contradiction solving is actually a very useful device in the dialogue between QCA and 'thick' case knowledge. It also helps the user to loop back to the phase of case selection. After contradiction resolution, it is also useful to check for the necessity and sufficiency of each condition/combination with regard to the outcome in this step. A condition is sufficient for the outcome if it is always present whenever the outcome shows up in the cases. In other words, there should be no single case of the condition without showing the outcome. A condition is necessary if whenever the outcome is present the condition is present as well. In other words, there should be no case with the outcome without the presence of the condition. Boolean mimimization is the core of this phase of QCA. The minimization process decides about the inclusion of "logical remainders" into the QCA analysis. Logical remainders are configurations of conditions across a truth table that have no cases (outcome= [0]). If all logical remainders are excluded from the analysis, the most parsimonious minimal formula is produced. If only those logical remainders that are in line with the researcher's theoretical and substantive knowledge of the subject (and cases) are included into the analysis, the 'intermediate solution is produced. To make the decision, the researcher should in fact exercise with a question, as follows, about the logical remainders: 'considering the cases I have observed so far, if I were to observe cases with such and such

values on the conditions in this configuration, I would rather expect the outcome value to be [1] (or [0])'. However, implementation of a minimization process, once for the outcome and another time for the outcome negation, brings its own challenges as well. Namely, there is a chance that the researcher might make "contradictory simplifying assumptions" in the midst of the minimization process. Such contradictory assumptions happen when the same logical remainder is both used for minimization of the outcome present configurations and also outcome absent configurations, thus committing two contradictory assumptions about the outcome value of that logical remainder. However, the strategy to be used for the resolution of such contradictions is similar to the ones detailed above for contradictory configurations. This matter, however, shows the importance of case knowledge and iterative returning to cases in QCA.

3. 1. 3 Downstream: interpretation

It should be emphasized that the analytic part of QCA is only one step in the whole QCA process. A series of crucial operations must still be undertaken, otherwise the whole point of QCA is missed out. Once again "returning to the cases" plays an essential role in this phase. The following steps are normally followed in this phase: (1) factoring out conditions in the minimal formulae; (2) case-by-case interpretation; (3) cross-case patterns interpretation; (4) and limited contextual/local/historical generalization. Sometimes it is possible to make the minimal formula more summarized. Minimal formula is called as solution or path by some scientists as well. In fact, one can consider the formula as a linear algebraic equation and factor out some repetitive conditions in order to make the formula more comprehensible. However, one should consider that factoring does not mean minimization and no further parsimony to the formula is possible in this stage. In addition to the presentation of minimal formula, the interpretation of it must also accompany the QCA findings. Interpretation means that causal questions about ingredients and mechanisms that produce the outcome (or its negation) should

be asked and answered based on the revealed configurations. Interpretation is totally case driven, as QCA is basically an instrument to better understand the complexity of cases. Interpretation of minimal formula usually happens in the three following ways: case-by-case interpretation, cross-case interpretation, and limited generalization. In case-by-case interpretation, some individual narratives are retrieved to extrapolate on conditions within minimal formula. In cross-case interpretation, similarities or dissimilarities in case narratives are retrieved to support, challenge, or judge the whole minimal formula or its constituent conditions. In fact, with the use of QCA as a heuristic help, one can cross-examine the case narratives that cluster within solutions. The "limited generalization" interpretation goes beyond the observed cases in the local context to make propositions, with appropriate caution, about cases in other contexts. This view on generalization is more modest than statistical inference which allows more broad generalizations. This modesty is in line with complex realists' take on the knowledge of social cases as normic and context-driven. However, this kind of generalization, interestingly, can sometimes lead to the proposition of a model about the phenomenon of interest which can be examined in other contexts. Normally this step is the place where a QCA-driven study finishes.

4. QCA and colorectal cancer screening behaviour

After a relatively brief description of all QCA phases and steps and before explicating its mathematical and analytical details, it is necessary to have a brief overview of the relevance of QCA for investigation of colorectal cancer screening behaviour and the way it differs from current quantitative and qualitative approaches. QCA differs from quantitative correlation-based analysis of screening behaviour as it does not look for independent and net effects of social and psychological determinants of screening behaviour. In fact, QCA reveals the ways those determinants configure (sit together) to produce screening behaviour and their net effects are not important. This configurational approach is somehow similar to "interaction term" in

quantitative analysis but it is more sophisticated. To be precise, interaction terms are not normally reported in majority of quantitative studies and when reported they only cover interactions between two variables and not more. In fact, higher level interactions are not interpretable. In contrast, QCA allows us to see multiple ways that determinants of screening interact with each other to produce the screening behaviour. Moreover, correlational studies and models do not distinguish screening behaviour presence from its absence, while QCA treats them as two different qualitative states that are produced by different configurations of determinants that need separate analysis each. This approach provides richer information about screening behaviour and its determinants in QCA-based studies. Finally, against quantitative studies of screening behaviour that are de-contextualized, configurational studies give huge importance to context within which cases dwell. This is the context that allows specific configurations/interactions of conditions to build-up, consolidate, and produce the behaviour.

QCA also differs from qualitative research on colorectal cancer screening behaviour in several ways. It is like qualitative studies as it allows for a case-oriented collection of rich narrative data about screening behaviour, its determinants, and the context. But it differs from such studies as it allows for an effective summary of that rich information, in form of screening behaviour conditions for each case, which paves the way for a systematic comparison across cases. Moreover, QCA adds the configurational thinking to qualitative studies on colorectal cancer screening behaviour as, similar to quantitative studies, these studies also fail to illustrate how relevant conditions sit together to bring about the screening behaviour. Necessity and sufficiency-oriented thinking about screening behaviour conditions and configurations is the next insight that QCA adds to the current qualitative (and quantitative) studies on colorectal cancer screening behaviour. Normally, current screening-focused qualitative (and quantitative) studies lack the methodological rigor to show how necessary and sufficient the conditions and revealed configurations are for the screening behaviour. This insight can be of a policy-making

importance as it illustrates the leverage points (conditions/configuration of high necessity and sufficiency) that interventions can be directed towards for improvements in screening behaviour rates.

To summarize, through a configuration, sufficiency, context, and case-oriented thinking, QCA helps us bridge between sheer richness of information gathered in qualitative studies and simplistic parsimony of quantitative correlation-based studies on colorectal cancer screening behaviour. It is hoped that this approach will help us better understand the complexities of colorectal cancer screening behaviour.

5. Boolean algebra conventions and operations

QCA works based on Boolean algebra conventions and operations. Therefore, a basic presentation about these conventions and operations will first be offered in the following section and then the QCA mathematical operations will be discussed.

The main conventions of Boolean algebra are as follows (Table 3):

1- An uppercase letter represents the [1] value for a given binary variable. Thus [A] is read as: "variable A is present"

2- A lowercase letter represents the [0] value for a given binary variable. Thus [a] is read as: "variable A is absent"

3- A dash symbol [−] represents the "*don't care*" value for a given binary variable, meaning that it can be either present (1) or absent (0). This also could be a value we don't know about (e.g., because it is irrelevant or the data is missing). It is not an intermediate value between [1] and [0].

Boolean algebra is also based on a few basic operators. The three chief Boolean operators are as follows:

1- Logical “AND”, represented by the [*] (multiplication/conjunction/intersection) symbol: N*B. It can also be represented with the absence of a space: [A*B] can also be written as: [AB]. AND operator does not mean multiplication (×) in a sense that it does in conventional algebra, but it means that a case have both of the components. In set theory language, it means that a case belongs to a place where sets intersect (Figure 4). To calculate a case’s score in a conjunction, the minimum value of the case’s membership across the combined sets should be considered. For example, if a case’s scores in N and B sets are (0) and (1); the case’s score in the conjunction becomes 0.

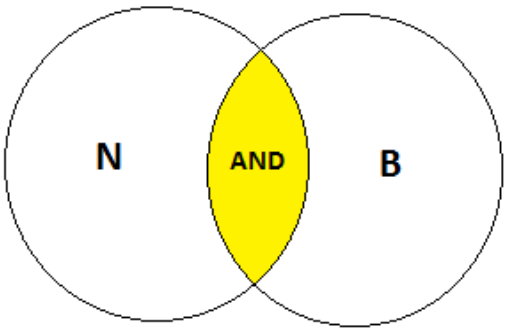


Figure 4. A schematic illustration of intersection of two sets.

2- Logical “OR”, represented by the [+] (addition/disjunction/union) symbol: N+B. This Boolean operator, in fact, describes the logical alternatives. The alternative is realized if at least one of the constituent components (set) is present. OR operator does not mean addition (+) in the sense that it does in conventional algebra, but it means that a case has at least one of the elements connected through this operator. In set theory terms, a case is at least a member of one of the sets. To calculate a case’s score in a disjunction, the maximum value of the case’s membership across the united sets should be considered (figure 5). For example, if a case’s scores in N and B sets are (0) and (1); the case’s score in the disjunction is 1.

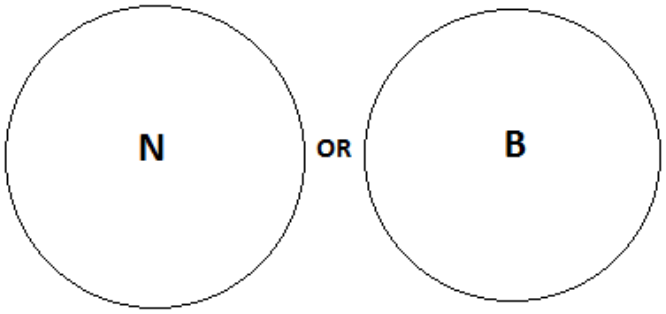


Figure 5. A schematic illustration of union of two sets.

3- Logical “NOT”, represented by [~] (negation/complements) symbol: ~N and ~B. In set theory language, negation of a set contains all the cases that do not belong to that set (figure 6). To obtain a negation of a Boolean statement for a case, one should simply subtract the case’s score for a component from 1. For example, if the score of a case for a component is 1, the negation score is 1-1= 0. However, if the case’s score is 0, the negation score is 1-0= 1.

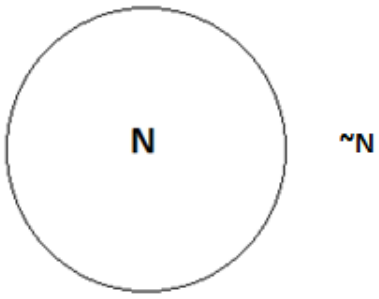


Figure 6. A schematic illustration of negation concept

Table 3. Boolean conventions and operators

Boolean conventions	Boolean operators
1- An uppercase letter representing the 1 value for a given binary variable: B is read as "variable B is ***present***" 2- A lowercase letter representing the 0 value for a given binary variable: b is read as "variable B is ***absent***" 3- A dash symbol [−] representing the "don't care" value for a given binary variable, meaning it can be either present (1), or absent (0), or even missing.	1- Logical "AND", represented by the (*) (multiplication/conjunction/intersection) symbol: N*B. It can also be represented as: AB. In set theory language, it means that a given case belongs to place where sets A & B intersect. 2- Logical "OR", represented by the (+) (addition/disjunction/union) symbol: N+B. In set theory terms, it means that a given case is at least member of one of the sets, A or B. 3- Logical "NOT", represented by (~) (negation/complements) symbol: ~A and ~B. In set theory language, negation of a set contains all cases that are not belonging to that set.

6. Operations in complex expressions

Usefulness of above-mentioned logical operators are better unfolded when they are used in combinations to create complex expressions. Complex expressions are called "solution terms" in set theory.

There are three rules in the combination of expressions. (1) Commutativity: it means that the order by which two or more components (conditions/sets) are connected by AND and OR is irrelevant. For example, A*B is not different from B*A. (2) Associativity: this rule means that when one uses same operator, the sequence by which the elements are combined (by AND or OR) is not important. For example, in an attempt to create a conjunction with three elements of A, B, and C, the following combinations would be same: (A*B)*C = A*(B*C) = (A*B)*C.

(3) Distributivity: it means that when both OR and AND operators are used in same logical expression, elements that are shared by different combinations can be factored out. For example, A*B + A*C= A* (B+C).

The logical operations of intersection, union, and negation can be applied to complex expressions as well. For example, one can calculate the negation, intersection, and union of the two following expressions: F + G*(~H + ~I) and ~FG + G~H. The negation of complex logical expressions obeys DeMorgan's Law. This law has two basic rules: (1) if a statement is negated, all the single components within the expression that are present become absent and vice versa. For example, if one aims to negate A + B, A become ~A and B becomes ~B. (2) In negation, the logical operators should be inverted too. The OR (+) operator becomes the AND operator (*) and vice versa. Then, negation of A + B becomes ~A*~B.

In terms of the calculation of cases' scores in complex expressions, the membership score should equal to a single number. For example, if we take the expression F + G*(~H + ~I) and assume that a case score for F, G, ~H, and ~I are as follows: 1, 0, 0, and 1, the score of the case for this expression then becomes 1. We have to start from the parenthesis (~H + ~I), just like in conventional linear algebra. Because of the logical OR, the maximum membership score should be considered, which is 1. Then we have to calculate the score for the multiplication G*(~H + ~I), i.e. we have to look for the minimum membership score, i.e. 0. Eventually, the final logical OR in F + G*(~H + ~I) calls us to consider the maximum membership score between the F and rest of the expression, which is 1. All these conventions, operations, and rules are presented here to better facilitate the understanding of calculations that are undertaken by a software, normally hidden from researchers' eyes, to calculate the memberships and outcome value for truth table configurations and their minimization.

Regarding specific terms used in set theory, “condition” and “outcome” are used instead of “independent variable” and “dependent variable” terminologies that are used in a conventional research context. If there is a condition comprised of several other conditions linked by the AND operator, this might be called as a path, a conjunction, or a term. If several such paths combine together with logical OR, the result is called a solution term/formula. “=” cannot be used in set theory as we have no equation , but only logical expressions and relations that are asymmetric.

7. Set theory/relations

All the analyses by QCA are based on set theory relations. Set theory is about how social/natural cases (for example individuals) belong to sets of similar cases and what can be (causally and relationally) elicited from such belongings. For example, when a researcher argues that “religious people are conservative in terms of politics”, they claim that religious people are a subset of the set of conservative people, and that, implicitly, being religious is a cause of conservatism. Similarly, when a researcher claims that stronger civil society is necessary for being a developed country, they imply that developed countries are a constituent subset of countries with strong civil societies. Therefore, the relationship here is a constitutive one. Interestingly, when the set relations between phenomena are causal or constitutive, they should be explicated in some way. To be precise, they should be explained by some theoretical information in order to justify the relations.

Asymmetry is one of the defining features of set relations. For example, if a researcher claims that developed countries are democratic, they in fact claim that developed countries are a subset of democratic countries. Interestingly, this claim is not challenged by the fact that there are some under-developed countries that are democratic, for set relations are not symmetric as the correlation-focused strategies assume. Indeed, the set of democratic countries could have some

subsets from both developed and under-developed countries. This matter cannot be true for correlational analysis in conventional statistics as correlation should be symmetrical.

In summary, set relations are important for social research in four ways: (1) they include causal and integral relations that link social phenomena and are not only definitional relations; (2) they require explication by theory and knowledge; (3) they are at the basis of theorizing in social science as theories are verbal statements, which are set theoretic in nature; and (4) they are asymmetric.

There are two types of set-theoretic relations that can be explained in terms of searching for commonalities across cases in complex case studies. The first type identifies the causal conditions/or combination of conditions that are common among the cases with same outcome. This type of relation is called ***necessary*** conditions/relations. To be precise, a condition is necessary only when the outcome is present, the condition is present too. The outcome cannot be achieved without the given condition. In another words, the outcome is a subset of the condition (figure 7).

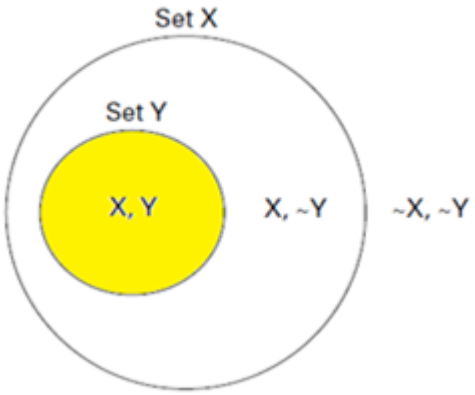


Figure 7. A schematic illustration of a necessary relation

Here, only cases that are members of the outcome (Y) are important and the value of condition (X) for these cases is of significance. An interesting point is that most of the times there is no single condition but a combination of conditions and the research should investigate whether the combination is necessary for the outcome or not. Considering what was pointed to in Boolean logic, there are two kinds of combinations: Logical OR and Logical AND. Interestingly, taking this matter into account that one should take lower values when considering the Logical AND relations, the chance of having such a relation that can pass necessary relation is very dim, for to be necessary the condition should have equal or higher membership value than the outcome. Logically, therefore, no "AND" combination can pass the necessary test only if it is comprised of single conditions that already passed the necessary condition. Therefore, investigation of necessary conditions will start from single conditions and if they prove to be necessary, then their combinations will be tested. In contrast, Logical OR combinations are more apt for necessary analysis as they take the maximum membership value in determining the cases membership in the union. In fact, union relations create a new set that is big enough to have more cases and be a possible superset of outcome and potentially necessary for it. The union can even include the conditions that were not necessary for the outcome by their own. However, this matter, creating unions and studying their necessity, should be made very carefully and there should be some theoretical substantial arguments about plausibility of combining the conditions that are to act as "functional equivalents" of some high-order concepts.

The second type identifies the cases with same causal conditions to examine whether they show same outcome. This type of relations is called ***sufficient*** conditions/relations (figure 8). A condition can be sufficient only when it is present in the cases, the outcome is also present. No case should be observed that has the condition but without the outcome. In other words, a condition is a subset of the outcome.

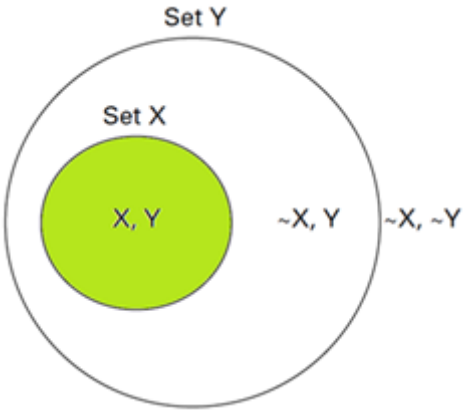


Figure 8. A schematic illustration of a sufficient relation

Here only the cases that are members of X are relevant for assessment of sufficiency of the relationship between X and Y. For example, cases within the ~X are irrelevant for sufficiency assessment as set relations are asymmetric. In fact, X and ~X are qualitatively two different phenomena that play two very different roles in causing the outcome. If one approves of the sufficiency of X for Y, they have no right to approve of (out of such a relation observed) the sufficiency of ~X for ~Y (because of that asymmetry (asymmetrical causality)). To summarize, when someone approves that X is sufficient for Y, the following propositions can be made: (1) cases with both X and Y are expected to be seen. (2) No cases with X and ~Y are expected to be seen. (3) No expectation can be made about value of Y for ~X (it should be assessed separately). (4) The sufficiency claim can be rolled out only when cases with X and ~Y are seen.

Normally, single conditions and their negations are not solely sufficient for the outcomes and the sufficiency investigation turns towards combinations of conditions. In fact, Logical AND combinations of conditions (e.g. A*B) are the combinations that one should check for their sufficiency. Interestingly, as Logical AND combinations take the minimum value in determining the score of each case for the combinations, the chance that a combination will be a subset of the outcome increases. Put simply, the more a researcher refines the conditions

(through combining more sets by Logical AND), the fewer cases display the outcome and it is more likely that those cases that display combinations are members of the outcome set. Anyway, the end of the sufficiency investigation would be a solution formula that sums up the sufficiency investigation results as something like the following:

$$\sim A + \sim B*C \longrightarrow Y$$

This reads as the absence of A *or* the combination of absence of B *and* the presence of C is sufficient for the outcome. It should be repeated here that Logical OR is an inclusive one and allows both alternatives to be present at the same time.

8. Causal complexity in set theoretic methods

When there is a reliable reason that the phenomenon under investigation emanates from a specific type of causal complexity, set relations related methodological approaches are of prime importance. The type of causal complexity that set-theoretic methods are good at unearthing have the three following features: equifinality, conjunctural causation, and causal asymmetry. Equifinality means that various mutual non-exclusive explanatory accounts for a phenomenon can exist simultaneously. Conjunctural causation means that the effects of a single cause only show up in specific combination with other causes. Causal asymmetry means that (1) a causal effect ascribed to a cause (condition) always points to only (and only) one of the two qualitative states, presence or absence, which the cause can potentially take on. (2) The outcome in any solution term can only (and only) show up in one of its potential qualitative states, presence or absence, that it can take on. Put another way, asymmetrical causation implies that both the occurrence and the non-occurrence of social phenomena require separate analysis and that the presence and absence of conditions might play crucially different roles in bringing about the outcome (quite contrasting correlation and regression analyses).

Interestingly, all these features are interlinked and derive from necessity and sufficiency concepts. If there is a sufficient but not-necessary condition, it implies equifinality as it means that there are cases that show up the outcome without the sufficient conditions. Therefore, there must be at least another sufficient condition, a direct consequence of asymmetry. The existence of a necessary but not sufficient condition implies of causal conjunction, as this necessary condition should be configured with other conditions to bring about the outcome. The following solution formula, as an example, may better illustrate the concepts discussed above about causal complexity:

A*B + ~B*C + D*~F $\longrightarrow$ Y

~A*F + B*C*~D $\longrightarrow$ ~Y

It is equifinal as shown by Logical OR; more than one path leads to the same outcome. It is conjunctural as shown by Logical AND; single conditions only play a causal role in the presence of other conditions. It is asymmetrical, as solution formulas for Y and ~Y are not a logical mirror of each other.

More importantly, equifinality, conjunctural causality, and asymmetry allow us to handle with some types of causes that are of salient importance in qualitative research but are very hard to handle in quantitative methods. These causes (conditions) are neither necessary nor sufficient but are quite crucial to producing the outcome. These conditions are called INUS and SUIN conditions and the use of set-theoretic methods is very apt in order to reveal their roles.

INUS, quite frequent in QCA solutions, points to a condition that is an “Insufficient but Necessary part of a combination which is itself Unnecessary but Sufficient for the outcome”. The following example better illustrates this issue:

A*B + ~B*C + D*~F $\longrightarrow$ Y

Condition A can only produce the Y through combination with B. It is in fact insufficient (I) per se but necessary (N) to produce a sufficient (S) conjunction with B. The sufficient conjunction A*B, in turn, is not the only path to Y, so it is unnecessary (U).

SUIN points to a condition that is a "Sufficient, but Unnecessary part of a combination that itself is Insufficient, but Necessary for the outcome". SUIN is more related to necessity analysis. Necessary conditions are created by Logical OR operators and OR-combined conditions are functional equivalent of some higher-order necessary conditions. In fact, SUIN conditions are constituents of such higher-order constructs. The following formula better illustrates the SUIN concept:

(A+B) * (C+~D) ⟵ Y

The two unions A+B and C+~D are the necessary conditions for the outcome. However, taken alone they are insufficient to bring about the outcome. Single components of the unions are, on the other hand, not necessary themselves, but sufficient (mutually substitutable) elements of the necessary unions.

9. Evaluation of set-relations

There are two measures to evaluate the set-theoretic, necessary and sufficient, relations: *consistency* and *coverage*. Consistency is just like a significance test and shows whether a causal path is worth close attention or not. Coverage, like a strength test, illustrates the relevance or importance of a set relation. Just as with significance and strength, in which one might have a significant but weak correlation, it is possible to a have a highly consistent but weak (low coverage) set relation. For sufficiency relations (the causal set is a subset of the outcome set), consistency measures the degree to which all the cases in a causal path/recipe (combinations of causes) represent the outcome. By contrast, coverage gauges the degree to which a causal path accounts for the overall number of outcomes. In fact, coverage represents

the importance of a causal recipe. For necessity relations (the outcome set is a subset of the causal set), consistency evaluates the degree to which outcome cases agree in showing the causal path. The coverage, by contrast, evaluates the degree to which cases with a causal path represent the outcome.

9.1. Set-theoretic consistency for sufficient relations

A sufficiency relation assessment starts from the observation of some causal conditions (C) towards observation of the outcome (O). Consistency can be measured by the proportion of the cases within a causal path that represent the outcome. In fact, in analysing sufficiency consistency (inclusion), the question is how many times O has been observed considering the total presence of C.

$$Consistency\ (C) = \frac{\sum_{i=1}^{n} O_i = 1 \mid C_i = 1}{\sum_{i=1}^{n} C_i = 1}$$

If consistency score is high, this is consistent with this judgement that C is highly sufficient for O. Perfect consistent set relations are hard to find in social sciences. However, the consistency score can show the degree to which a (perfect) set relation is approached. The consistency score ranges from 0 (no consistency) to 1 (perfect consistency), and it should be as close to 1 as possible. However, if the consistency value is lower than 0.75, the existence of a consistent set relation becomes difficult to defend.

9.2. Set-theoretic coverage for sufficient relations

Set relations in QCA allow for two interesting phenomena: causal complexity and equifinality. However, it is methodologically wise to relatively assess the number of cases falling into each path (that lead to the outcome) to see how empirically important each path is. If a causal path accounts for a large proportion of outcome cases, then it is more empirically important than other paths. The measure that assesses such a matter is called coverage. To be precise, in

analysing sufficiency coverage, the question becomes how many times O has been observed considering the total presence of O.

$$Coverage\ (C) = \frac{\sum_{i=1}^{n} O_i = 1 \mid C_i = 1}{\sum_{i=1}^{n} O_i = 1}$$

If coverage is high, this is consistent with this hypothesis that C is not trivially sufficient for O. While there is sometimes a trade-off between consistency and coverage, it is wise to first assess and prove the consistency of any causal path. In fact, it is pointless to assess the importance of a cause without proving first that it is a consistent subset of outcome.

Table 4 illustrates the relevance of cells in analysis of consistency and coverage, considering the previously mentioned formulas. Cell 2 is relevant for both consistency and coverage analysis, cell 3 is totally irrelevant, cell 4 is relevant for consistency, and cell 1 is relevant for coverage analysis.

Table 4. Analysis of consistency and coverage for sufficient relations

		C	
		0	1
O	1	(1) Relevant cases (coverage)	(2) Relevant cases
	0	(3) Irrelevant cases	(4) Relevant cases (consistency)

9.3. Set-theoretic consistency for necessary relations

Analysis of necessity normally comes before sufficiency analysis. Necessity analysis starts from observation of the outcome (O), towards observation of the condition (C). In the analysis of consistency of necessary conditions, the question is "how many times has C been observed considering the overall presence of O?" The formula to assess the consistency of necessary conditions is as follows:

$$Consistency\ (C) = \frac{\sum_{i=1}^{n} C_i = 1 \mid O_i = 1}{\sum_{i=1}^{n} O_i = 1}$$

If the consistency score is high, there is a support for this hypothesis that C is necessary for O.

9.4. Set-theoretic coverage for necessary relations

In the analysis of necessity coverage, the question is "how many times is C present in a causal path considering the overall observation of C?" If necessity coverage is high, it shows that C is not trivially necessary for O.

$$Coverage\ (C) = \frac{\sum_{i=1}^{n} C_i = 1 \mid O_i = 1}{\sum_{i=1}^{n} C_i = 1}$$

Table 5 illustrates the relevance of cells in the analysis of consistency and coverage of C in a necessity relation. Cell 2 is relevant for both consistency and coverage analysis, cell 3 is totally irrelevant, cell 4 is relevant for coverage, and cell 1 is relevant for consistency analysis.

Table 5. Analysis of consistency and coverage for necessary relations

		C	
		0	1
O	1	(1) Relevant cases (consistency)	(2) Relevant cases
	0	(3) Irrelevant cases	(4) Relevant cases (coverage)

Interestingly, the calculation of consistency for a sufficient set relation is identical to the calculation of coverage of a necessity relation and vice versa. However, in both cases consistency analysis should precede coverage analysis.

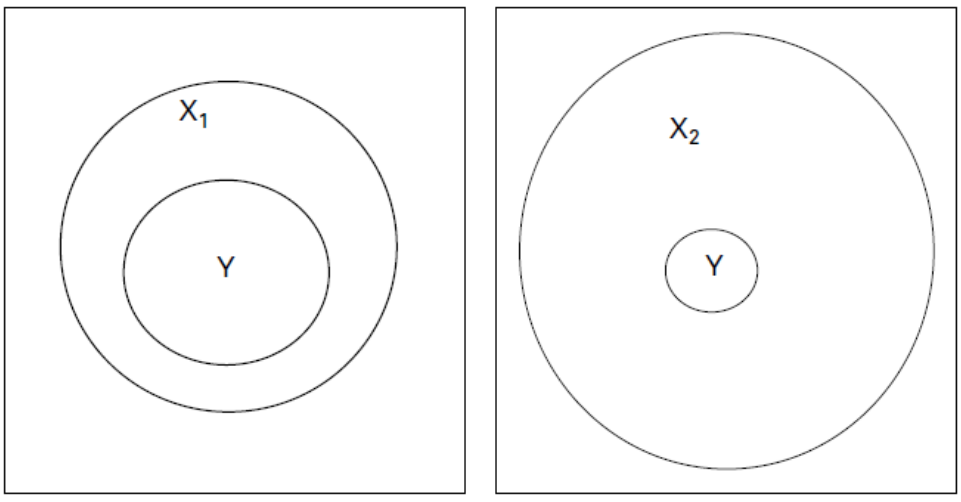


Figure 9. A schematic illustration of coverage concept in a necessity analysis

Figure 9 may better illustrate the coverage concept. Both conditions of X_1 and X_2 are perfect consistent supersets of the outcome Y. However, X_1 covers a higher proportion of Y than X_2 and is more relevant as a necessary condition for Y. X_2 is a trivial necessary condition for Y, as there are considerable cases with Y that occur outside of X_2.

9.5. Division of coverage

When there is more than one sufficient causal path for the outcome (equifinality), coverage assessments of causal paths would provide evidence of their empirical importance. However, this "raw" coverage can be complemented with "unique" coverage assessment by partitioning the coverage in a similar way that variation is partitioned in conventional (regression) analysis. To calculate the unique contribution of each variable to explain outcome variation in a regression analysis, the reduction in the explained variation that happens when the corresponding variable is removed should be considered. The value of reduction, in fact, is the unique contribution of the given variable. However, unique coverage is even more important as there is more than one causal path in set-relations and one case can settle in more than one path. Here an example can better describe the concept of partitioning the coverage. Let's assume that two paths of A*B and C*D display the outcome of interest. The coverage assessment shows that the first path accounts for 25% (coverage= 0.25) of outcome instances and the second account for 30% (coverage= 0.30). However, when the research adds their coverage together (A*B + C*D), it is revealed that their union accounts only for 35% (coverage= 0.35) of instances. The reason that the contribution of the union is less than the sum of two paths (0.35 < 0.55) is that these two paths partially overlap. In other words, there are cases that combine all the four conditions (instances of A*B*C*D) and they are counted twice when calculating the raw coverage of two paths. However, it is possible to partition the total coverage (0.35) and calculate the unique coverage of A*B, C*D and their overlapping by

subtracting the raw coverage of each path from the overall coverage. The unique coverage of A*B is 0.35-0.30=0.05 (5 instances of the outcome); the unique coverage of C*D is 0.35-0.25=0.10 (10 instances of the outcome). The remainder of total coverage (0.20; 20 instances of the outcome) is due to the overlap of the two paths (A*B*C*D). The unique coverage, in fact, can better reveal the empirical importance of each path to the outcome.

The following figure (Figure 10) can better help in understanding the difference between 2 types of coverages. The solution term shown in the figure equals:

$$X_1 + X_2 + X_3 \longrightarrow Y$$

The rectangular represents the all of available cases. X_1, X_2, X_3 are the three sufficient paths (sub-sets) to the outcome Y (super-sets). As can be seen, all the paths are fully consistent sufficient conditions for Y. However, they differ in terms of their coverage, unique and raw. The raw coverage is the size of a path (set) within the Y. For example, the raw coverage of X_2 is higher than $X_1$and X_3, as the area it covers (IV) is bigger than (II) and (III). The unique coverage is the area that a condition (set) covers uniquely, with no overlap with other conditions. For example, in this figure, $X_1$and X_3 partially overlap. Therefore, the unique coverage of X_1 equals the area (I), while the unique coverage of X_3 equals the area (III). For X_2, the raw and unique coverage values are the same. The solution coverage is the sum of (I) to (IV).

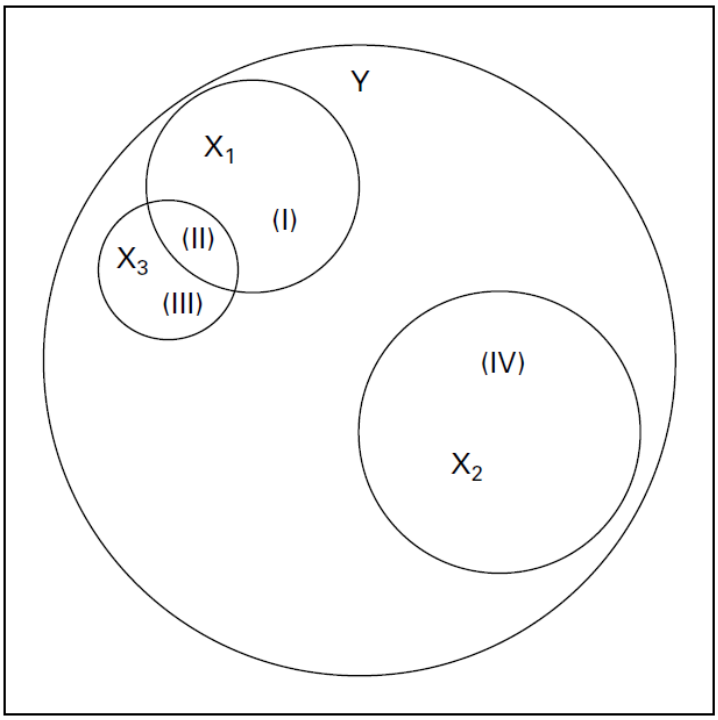


Figure 10. A schematic illustration of raw, unique, and solution coverages

9.6. Consistency and coverage relationship

Interestingly, there is an inverse relationship between consistency and coverage, i.e. higher values of consistency come with lower values of coverage and vice versa. This happens as follows. The consistency value can increase by the addition of some new conditions through logical AND (e.g. A*B*C to A*B*C*D by addition of condition D). However, the more conditions that are added to a path, the more difficult membership of it becomes. This in turn makes the path ever smaller and the chance of having it as a consistent subset of the outcome increases. At the same time, however, as membership within this path becomes harder, the less portion of outcome is covered (cases with outcome) and the coverage value decreases. A similar logic applies to necessity too. Here the consistency increases by addition of conditions through logical OR (e.g. A+B+C to A+B+C+D by addition of condition D). The more conditions are added, the easier it gets for a case to become a member of the path. In fact, the path gets bigger and bigger and the chance of having it as a superset of the outcome increases.

However, like conjunction, as the path become bigger and bigger, the more number of cases fall into it and the difference between size of the path and the size of the outcome increases, making the path a trivial necessary condition for the outcome.

10. Truth table

Truth tables are at the heart of QCA analysis, both as an approach and as a technique. QCA as an approach is a research phase that is to produce a truth table. A truth table contains the empirical information gathered by a researcher. As a technique, QCA aims to formally analyse the truth table, a process called as logical minimization, in order to reveal the sufficient and necessary conditions. Just like data matrices, each column in a truth table represents a variable (or a set). However, the rows denote something completely different. Instead of a case the rows denote a logically possible combination (logical AND) of conditions. As there can be two qualitatively different states for each condition (i.e. present or absent), the total number of rows can be calculated by the formula 2^k, where k stands for the number of conditions. Each row represents a qualitatively unique configuration of conditions so that the differences between cases across the rows is a difference in kind and not in degree. Interestingly, not every row can be actualized (have cases) in the social reality and only some rows are able to accommodate some cases.

There are three steps to be taken to construct a truth table from a data matrix. First, all 2^k logically possible combination of conditions are written down. Second, each case from the data matrix is accommodated into one, and only one, row according to the values (0 absent, 1 present) of conditions within the case. Third, an outcome value has to be given to each row. This value is determined by the outcome value of cases that are accommodated into each row. In terms of cases, the value of 1 indicates that cases within each row show the outcome of interest and vice versa. From a configurations perspective, the value of 1 indicates that the

conjunction is sufficient for the outcome and vice versa. However, sometimes cases within a truth table row show different scores/values for the outcome. These rows are called contradictory rows and should be resolved.

11. Truth table analysis

Here one might ask why there is a need for analysis of sufficiency and necessity through a truth table when we can do it by simple data of empirical cases, as covered in the previous section. The reason is that truth tables provide a very sophisticated tool to identify the set relations through consideration of configurations. As has been seen, necessity analysis in the empirical cases is a bottom-up process and begins from simple sets proceeding to complex sets. In contrast, the analysis of sufficiency in a truth table is a top-down process, beginning first from possible configurations and then logically minimalizing the combinations proven to be sufficient. Interestingly, the analysis of necessity must not be dependent on a truth table and a bottom-up approach is preferable. The reason is that a conjunction (consisting of two or more conditions) can only be necessary if the constituent conditions are necessary on their own.

The outcome column in a truth table illustrates whether a row, or configuration of conditions, is sufficient for the outcome or not. This matter is indicated by value 1 in the outcome column, indicating that the condition is a subset of the outcome. However, there are normally several such sufficient rows in a truth table. As researchers we want parsimonious answers to questions about the sufficiency of conditions. In order to have such a succinct answer, Boolean algebra rules should be used. The process of having such an answer, a process called logical minimization, should then be pursued. In fact, an algorithm called Quine-McCluskey algorithm is used to logically minimize various sufficient conditions in a truth table.

The first step in using a Quine-McCluskey algorithm is to create a Boolean expression of all the rows (primitive expressions) that are sufficient for the outcome. For example, the result of this step can be something like this:

~A~B~C + ~A~BC + ~AB~C + ~ABC + A~BC ⟶ Y.

However, this formula is the most complex way of reporting sufficiency relationships. The second step, then, is to report those relationships in a less complex expression. This process is called logical minimization, which has certain principles. The first principle of logical minimization is: if two truth table rows that are in relationship with the outcome are different in only one condition – the condition is present in one row and absent in another one - then this logically redundant condition can be removed from the expression of sufficiency. For example, condition C is present and absent in the two first paths of the above mentioned expression:

~A~B~C + ~A~BC + ~AB~C + ~ABC + A~BC ⟶ Y.

Therefore it is logically redundant and can be omitted:

~A~B + ~AB~C + ~ABC + A~BC ⟶ Y.

The redundancy of condition C means that condition A is sufficient for the outcome regardless of the value that C takes. The condition C can be dropped from the second and third paths of the current expression as well:

~A~B + ~AB + A~BC ⟶ Y.

Such a process can follow with the rest of the expression until there is no redundant condition to be removed. The final expression then will be the following:

~A + ~BC ⟶ Y.

This expression is logically equivalent to all the complex and intermediate expressions and conveys same information about the truth table. However, the decision about the solution (complex, intermediate, or parsimonious) that should be chosen for the report depends on the research and context-specific issues. For example, it is completely possible that a complex solution might better justify the occurrence of the outcome among some cases than the most parsimonious solution.

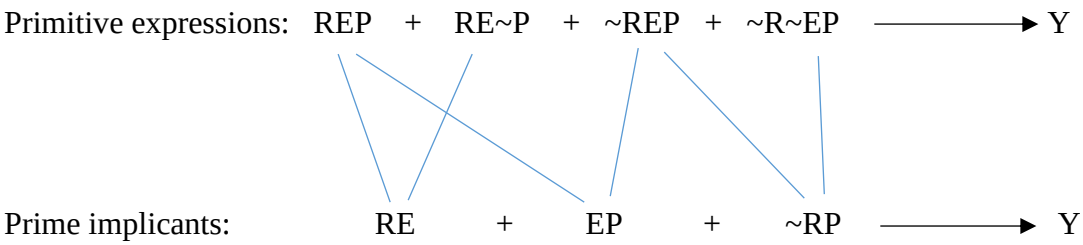
The second principle of logical minimization is to use prime implicants. In fact, there are some situations in which a parsimonious solution, resulting from the above-mentioned pairwise matching, can be further minimized. A prime implicant is the end product of the pairwise matching process. In fact, the parsimonious solution term reached by a pairwise comparison of conjunctions consists of prime implicants that are joined by logical OR. To further minimize the solution, the redundant prime implicants should be removed. For example, let us assume that we have the following expression out of a truth table:

REP + RE~P + ~REP + ~R~EP $\longrightarrow$ Y.

The pairwise matching of conjunctions then leads to the following parsimonious solution:

RE + EP + ~RP $\longrightarrow$ Y.

These three primitive expressions are prime implicants and cannot be further minimized by a pairwise matching process. However, it can have some redundant prime implicants. A prime implicant is logically redundant, and removable, if all the primitive expressions can be covered without having this implicant within the solution formula. This solution formula does not violate the truth value that the original truth table contains and the complex expression coefficient expresses. In order to find such an implicant, the following chart can be used:



The chart illustrates what primitive expressions are covered by the prime implicants. There should be no primitive expression that is not covered by the prime implicants, otherwise the truth value of the truth table is violated. However, there are some situations where a primitive expression is covered by more than one prime implicant. Here is the place where the logic of logically redundant prime implicants comes in: a prime implicant is redundant if, and only if, all primitive expressions are covered without it. In the above chart, EP is the redundant prime implicant and can be removed from the solution as primitive expressions covered by it (REP and ~REP) are covered by other prime implicants as well. We say *it can be removed* as sometimes the logic of research and the contexts mandates a researcher not to remove any prime implicants as they better help in the explanation of a phenomenon. However, if EP can be removed, the final solution formula can be written as follows:

RE + ~RP ⟶ Y.

After all these processes, a formula is produced that can meaningfully and appropriately represent the truth table. Such a prime implicant strategy, however, will not be used in the present study as we are afraid that it might conceal some important points.

12. Outcome non-occurrence

A consequence of the fact that set relations are asymmetric is that there should be a separate analysis of non-occurrence of the outcome, as occurrence and non-occurrence are two qualitatively different phenomena and in need of separate explanations. Therefore, all the steps from the data matrix to the logical minimisation of truth table should be repeated for non-

occurrence as well. More importantly, non-occurrence may require a different theory and hypothesis for explanation and causal analysis.

13. Parameters of fit for truth table

In reality, researchers often encounter truth tables that are incomplete and for which the above-mentioned necessity and sufficient analyses cannot be easily conducted. A truth table is incomplete if one or both of the following features show up. First, if there are some rows with cases whose membership scores for the row and for the outcome contradict the sufficiency statement. These rows are normally called contradictory or inconsistent rows. Second, if there are some rows for which there is no/less empirical evidence, called logical remainders. The reason for the presence of such remainders is a phenomenon called limited diversity which will be discussed in the following sections. The problem that these two features cause is that they make it difficult to decide whether those rows are sufficient for the outcome or not. Such a difficulty influences the minimization process as all the sufficient rows must be included in the minimization process. However, there are some strategies to deal with such problems.

13.1. Contradictory rows: definition and solution

The notion of contradictory rows in a truth table occurs when cases that belong to a row do not show the same membership scores in the outcome. Put another way, the same row can lead to both occurrence and non-occurrence of the outcome. It is logically contradictory as the very same row (combination of conditions) can produce both Y and ~Y, and it is not possible to decide whether it is sufficient for Y, ~Y, or neither. Consequently, they cannot be included in the logical minimization process. There are several strategies to resolve the contradiction either before the minimization process or during the process.

The first strategy is to bring a new condition into the truth table. The new condition will divide the contradictory row(s) (and all the rows indeed) into two new rows with cases that differ in

the scores for the new condition and the outcome, and possibly resolving the contradiction. The second strategy is to redefine the population of possible cases so that some cases might be included or excluded from the pool of cases, especially from the contradictory rows. However, the redefinition should be based on some firm theoretical justifications. The third strategy is to redefine and reconceptualise the conditions, the outcome, and their measurement. This redefinition should also be based on substantive theoretical arguments and after a very close and thorough examination of contradictory cases and understanding of the feasibility of such redefinitions. In this way, there might be a chance that the allocation of cases across the truth table rows will change and the contradiction will be resolved.

However, it is a routine in the QCA that the researcher cannot resolve the contradictory rows even after using the above mentioned strategies, or even due to impracticality of these strategies. Therefore, the researcher should opt for a process of logical minimization while there are some contradictory rows within the truth table. Interestingly, there are some methods to resolve the contradictions of the truth table during the minimization process, like the exclusion of all contradictory rows, inclusion of all contradictory rows, and computerized decision making about the (ir-) relevance of contradictory rows for the final solution. However, the standard strategy to deal with contradictory rows is the use of fit parameters, i.e. consistency and coverage parameters.

The consistency measure analyses the degree to which a truth table row (sub-set relation) deviates from a perfect set-relation (sufficient condition). The more a given row deviates from a perfect set relation, the less chance it has to be included into the minimization process. For example, one can assume of a row in which 9 out of 10 cases share the same membership score for the outcome, i.e. 90% of the set-relation is in line with a perfect set-relation. In another scenario, for example, only 6 cases out of 10 demonstrate the same score for the outcome. Therefore, only 60 percent of the evidence is consistent with a sufficient condition; this row

has a lower chance of being included into the minimization process. In fact, the consistency measure is a yardstick in the QCA to make a decision about whether a row should be included in the minimization process or not. However, the threshold by which to differentiate between consistent and inconsistent rows before the minimization process is a matter of concern. Many researchers believe that values close or below 0.5 should be dropped off as half of evidence is against a sufficient subset relation. However, the threshold can vary from a research to research.

Considering the theoretical background of the study, the richness and precision of information gathered about the conditions and the outcome (which made calibration easy), the relatively low number of cases, absence of contradictory rows, and the high value of consistency of rows, a threshold of 0.5 seems rational to set as the distinguisher point in the present study. However, unlike the consistency score, there is no threshold for coverage measure. The reason is that the consistency measure examines the degree of sufficiency of a subset relation, but the coverage measure illustrates the importance of a subset relation. A low coverage of conditions might be of huge importance in some cases, considering the context.

In addition, in terms of the parameters of fit for necessary relations, the consistency measure examines the degree to which an outcome can be seen as a subset of a condition. However, just like the consistency value for sufficiency, there should be a threshold for the consistency value for necessity in order to distinguish the truly logical contradictions. It is generally advised that a threshold of 0.9 would be advisable in the assessment of consistency of necessity. Any consistency value higher than 0.9 shows that the condition is not trivially necessary for the outcome. However, just like the coverage value for sufficient relations, there is no threshold for coverage value in the assessment of necessary relations as well, as a small value of coverage can be very significant in a specific context.

14. Limited diversity and logical remainders

The rows in a truth table that lack enough cases to be considered for a test of sufficiency are called logical remainders. These rows and the configuration of conditions within them are logically possible, but not empirically observed. The sufficient number of cases depends on the overall number of cases in a study; for studies with 10 to 100 cases the criterion for not considering a row as logical remainder is having at least 1 case. The way to deal with such logical remainders in drawing inference is crucial for set-theoretic methods. The presence of logical remainders is related to a phenomenon called "limited diversity". Although logical remainders make inference a challenge, they can be utilized for counterfactual analysis. There are three sources for the presence of limited diversity that should be mentioned. (1) Arithmetic remainders that happen when the number of possible configurations of conditions is higher than the number of cases studied. (2) Clustered remainders that show up when reality is structured (by social, historical, political and other processes) in a way that some types of cases do not exist in reality. (3) Impossible remainders that happen when some configurations of conditions never can happen in the world as we know it. The difference between clustered and impossible remainders is that the existence of the former is theoretically possible, while the latter cannot exist even in theory. This matter makes clustered remainders, alongside arithmetic ones, a good option for counterfactual analysis, while the impossible remainders are not.

15. The standard analysis procedure: using logical remainders to construct credible solution terms

Logical remainders are always present and assumptions about them shape the types of solution formulas drawn from a truth table. Therefore, there should be transparent strategies on which the decisions about remainders (those that are going to be included into the counterfactual analysis) are mounted. This matter becomes very important when we understand that it is

permissible, from formal logic and set-theoretic points of view, to have any kind of assumption about the remainders. In fact, whatever the remainder, as a counterfactual, chosen to be included into logical minimization, the solution term never contradicts the empirical information present in a truth table. As a result, when pure logic cannot help in the creation of plausible solution terms, other criteria are needed. Standard analysis procedure is the best proposed way to deal with logical remainders so far. In order to capture its logic, it is better to have a look at 3 different ways that solution terms (and the logical remainders within them) can be classified. The first dimension relates to set relations. If there are subset relations between truth table rows used in logical minimization, there would be subset relations between solution formulas as well. The second dimension, i.e. complexity dimension, captures the degree of complexity of a solution term. Finally, the third dimension, and the most important one, is about the type of counterfactuals. This dimension, in fact, classifies the assumptions about logical remainders. Such a classification is premised on the theoretical and logical qualities of logical remainders.

1) Dimension of set relation

Let's assume that there is a truth table like Table 6. If a researcher is interested in analysing the outcome Y (~Y), they could then analyse the rows 1, 4, and 5 of the table (2 and 3). However, the question is "what should the researcher do with rows 6, 7, and 8?" Different assumptions about these logical remainders will produce different solution terms. One assumption might be that all these rows lead to Y=1 and so they have to be included in the logical minimization; another assumption might be that all the rows lead to Y=0. So they should not be (are not sufficient to be) included into the logical minimization for Y=1; all the other types of assumptions, 6 other ones, fall between these two extreme assumptions. The solution terms for all the eight scenarios of assumptions will be as follows:

(a) AB~C + ~BC

(b) AB + ~BC

(c) A~C + ~BC

(d) A + ~BC

(e) ~A~B + ~BC + AB~C

(f) ~A~B + ~BC + AB

(g) ~B + A~C

(h) ~B + A

The first solution term is the most conservative one as it has no assumptions about remainders (all lead to Y=0). The interesting point is that solution (a) is a subset of the rest of the solutions. The last solution term (h) assumes that all the remainders are sufficient for the outcome and so this solution term is the *superset* of all other solution terms. Because of this subset relationship, no solution term contradicts the information provided in the truth table.

2) Dimension of complexity

In addition to set relations, the solution terms can be differentiated based on their complexity as well. By complexity we mean the number of conditions and OR and AND logical operators within each solution term. Going back to the previous example, the solution terms (h) and (e) are the most parsimonious and complex solution terms respectively. It is worth pointing out that the dimensions of complexity and set-relations are not always parallel and the end extremes of these two dimensions might be completely different from each other.

Table 6. A hypothetical truth table with three conditions

Rows	Conditions			Outcome
	A	B	C	Y
1	0	0	1	1
2	0	1	0	0
3	0	1	1	0
4	1	0	1	1
5	1	1	0	1
6	1	1	1	**?**
7	0	0	0	**?**
8	1	0	0	**?**

In the above example, the most parsimonious solution parallels with the solution (h) that is superset of all solutions, but it is not always the case and there are a lot of examples in which the most parsimonious solution is the superset of only some solutions.

3) Dimension of counterfactuals

In the Standard analysis, the most parsimonious solution term is used as an anchor and its subset solutions are only then accepted as legitimate to be included in the next round of analysis. In QCA terms, the Standard analysis rests on simplifying assumptions to conduct its analysis; they are simplifying assumptions as they only allow for the inclusion of logical remainders that lead to the most parsimonious solution term. However, it is interesting that neither complexity nor set relation dimensions depends on any deep knowledge about conditions to make assumptions about the remainders. Only after the use of parsimony criterion such knowledge becomes necessary to make counterfactual judgements about accepted logical remainders. However, now a distinction should be established between easy and difficult counterfactuals (i.e. accepted logical remainders). Easy counterfactuals accord with both empirical evidence and theoretical knowledge about the effects of conditions (on the outcome) that make up the logical remainder. Theoretical knowledge about the effects of conditions on

the outcome is called directional expectation. Difficult counterfactuals, on the other hand, only accord with the empirical evidence and lack any theoretical support.

Standard analysis, in a nutshell, consists of the following steps: (1) production of the conservative solution (no assumption about logical remainders), (2) production of the most parsimonious solution (inclusion of simplifying assumptions), and (3) the intermediate solution (inclusion of only easy counterfactuals). The intermediate solution term is a superset of the conservative solution and a subset of the most parsimonious one. It also sits between the conservative and the most parsimonious solution terms in terms of complexity. The reasons behind having an intermediate solution term are twofold: (1) the conservative term is too complex to be interpreted in a sound scientific and meaningful way, and (2) the parsimonious term might sit on an assumption about remainders that are not supported by sound theoretical knowledge. An intermediate solution term thus strikes a balance between complexity and parsimony, using theory as a guide about logical remainders that should be included in logical minimization. Standard analysis is indeed a powerful way to reduce the number of remainders that should be considered for minimization. The following figure (Figure 11) schematically shows the Standard Analysis procedure.

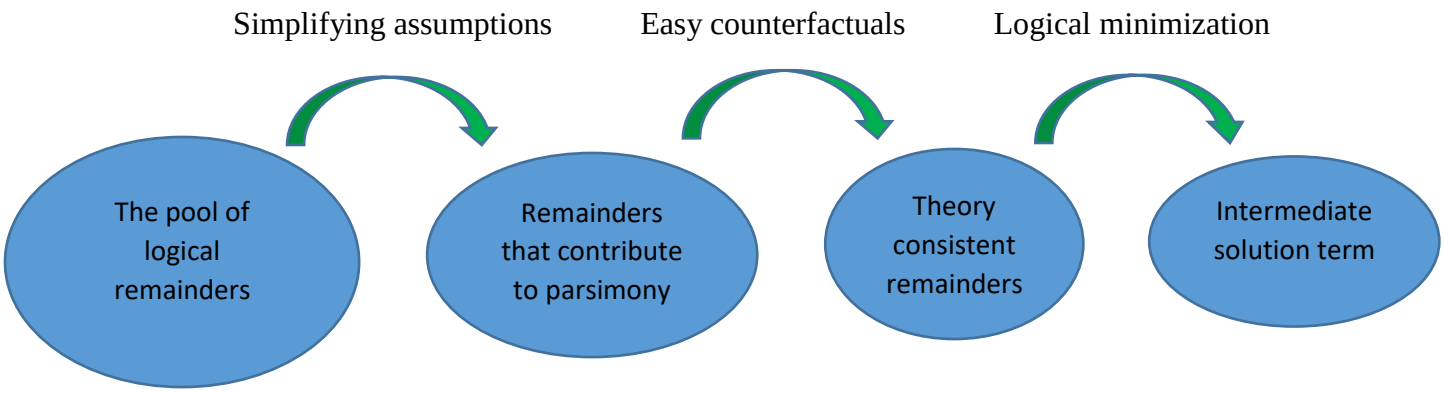


Figure 11. A schematic analysis of standard analysis procedure in QCA

The following example can better elucidate the meaning and process of the Standard analysis procedure. Table 7 shows a truth table in which there is empirical evidence for only 12 rows and the rest of the rows are logical remainders. The conservative solution of the truth table is as follows:

ABCD~E + A~BDE + A~CDE + A~B~C~D~E + ~ABC~D + ~AB~CD~E ⟶ Y.

It takes a lot of time and energy for someone to theoretically interpret this solution. However, to create the most parsimonious solution term, those remainders should be identified that (if assumed to lead to Y=1) make the term most parsimonious (done by computer software). The most parsimonious solution term, however, stands as follows:

A + B~C + B~D ⟶ Y.

This solution term relies on some counterfactuals' assumptions about logical remainders, some of which might be against current theoretical knowledge (difficult counterfactuals) and are in need of careful consideration. However, the most parsimonious solution term is of great importance in the Standard analysis procedure as it determines the remainders that are going to enter into intermediate solution term. In effect, the production of an intermediate solution term rests on the deletion of all difficult counterfactuals from simplifying assumptions and the inclusion of only easy counterfactuals in the minimization process.

Table 7. A hypothetical truth table for the production of intermediate solution

	Conditions					Outcome	Rows included in		
Rows	A	B	C	D	E	Y	Conservative solution	Most parsimonious Solution	Intermediate solution
1	0	0	0	0	1	0			
2	0	0	0	1	0	0			
3	0	0	1	0	1	0			
4	0	1	0	1	0	1	X	X	X
5	0	1	1	0	0	1	X	X	X
6	0	1	1	0	1	1	X	X	X
7	0	1	1	1	0	0			
8	1	0	0	0	0	1	X	X	X
9	1	0	0	1	1	1	X	X	X
10	1	0	1	1	1	1	X	X	X
11	1	1	0	1	1	1	X	X	X
12	1	1	1	1	0	1	X	X	X
13	0	0	0	0	0	?			
14	0	0	0	1	1	?			
15	0	0	1	0	0	?			
16	0	0	1	1	0	?			
17	0	0	1	1	1	?			
18	0	1	0	0	0	?		X	
19	0	1	0	0	1	?		X	
20	0	1	0	1	1	?		X	X
21	0	1	1	1	1	?			
22	1	0	0	0	1	?		X	X
23	1	0	0	1	0	?		X	X
24	1	0	1	0	0	?		X	X
25	1	0	1	0	1	?		X	X
26	1	0	1	1	0	?		X	X
27	1	1	0	0	0	?		X	X
28	1	1	0	0	1	?		X	X
29	1	1	0	1	0	?		X	X
30	1	1	1	0	0	?		X	X
31	1	1	1	0	1	?		X	X
32	1	1	1	1	1	?		X	X

In practice, therefore, the strategy of producing the intermediate formula focuses on conservative and the most parsimonious solutions and tries to determine which single conditions in the conservative solution and not in the most parsimonious one can be deleted using theoretical knowledge as a guide. In fact, the strategy of producing intermediate solution terms follows two principles: (1) only those single conditions can be dropped from the conservative solution that do not show up in the most parsimonious solution term; (2) only those conditions can be deleted from the conservative solution that are in line with existing theoretical knowledge. For example, if ~X is eligible to be dropped and the existing knowledge informs us that X leads to the outcome, then ~X can be crossed out.

As Table 7 shows, rows of 18-20 and 22-23 were taken into account to produce the most parsimonious solution in our example. The directional expectation in the example is that each single condition will contribute to the outcome Y if it is present (Figure 12).

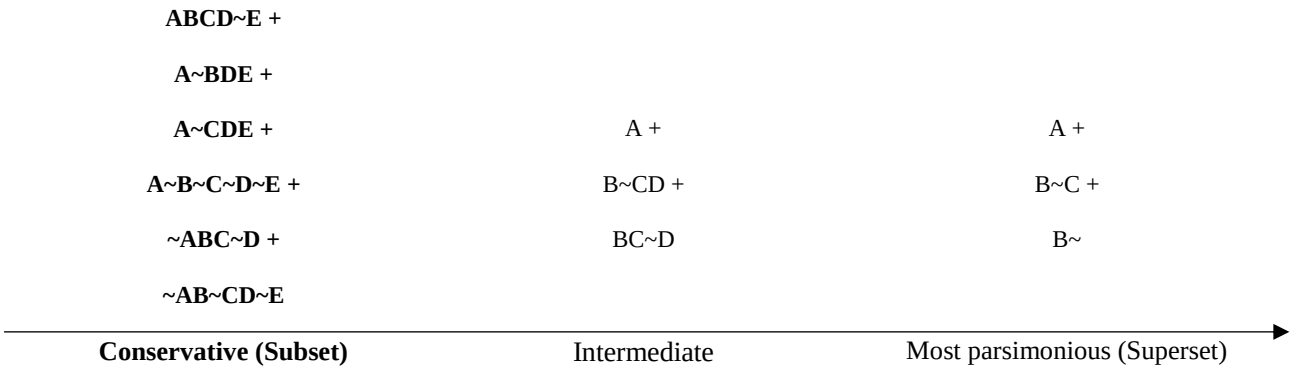


Figure 12. Conservative, intermediate, and most parsimonious solution terms for the table 7

To elucidate the standard analysis procedure, we can start from path B~C in the most parsimonious solution. This path is the superset of ~AB~CD~E in the conservative solution. Following our theoretical knowledge, ~A, ~C, and ~E can be dropped from this path, as their presence is important for the outcome. However, ~C cannot be dropped as it is a part of the most parsimonious solution term and should be an integral part of every intermediate solution formula. This process, therefore, leads to path B~CD within the intermediate solution formula.

This term emanates from assumptions about the remainder rows 20 (~AB~CDE) and 29 (AB~CD~E). These are easy counterfactuals since if row 4 (~AB~CD~E), which is only different from rows 20 and 29 in ~A instead of A and ~E instead of E, can lead to the outcome, then it is reasonable to assume that these two rows would lead to the outcome as well (if they were empirically observed). This process of comparing and dropping (conducted by software packages) continues and applies to each and every part of parsimonious solution as well until we reach to the following intermediate solution formula:

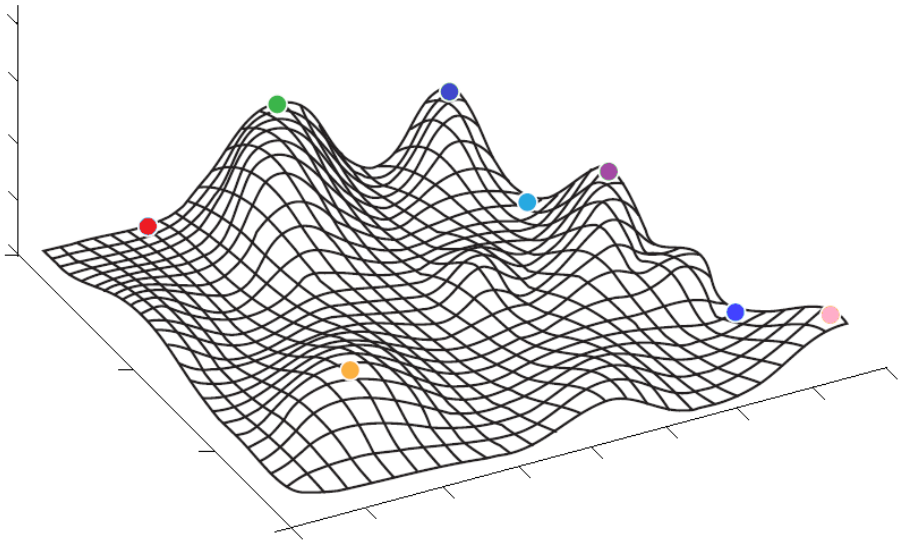
$A + BC{\sim}D + B{\sim}CD \longrightarrow Y.$

However, any of the three solution terms (most parsimonious, intermediate, and conservative) can be used as the anchor for interpretation of findings. However, the intermediate solution has some features that make it a more appropriate solution term for interpretation purposes: unlike the most parsimonious solution term it does not rely on difficult counterfactuals and unlike the conservative solution it includes the theoretical knowledge by easy counterfactuals.

16. Limited diversity and attractors

Before moving to the last part of the QCA process, i.e. the truth table algorithm, it is worth bringing an interesting insight from complex systems science into the fore and discussing its implications for limited diversity. Complex systems dynamic can be pictured across a phase-space coordinate on which there are, literally, an infinite number of points towards which a system can dispose. In complex systems science these points are called attractors (Figure 13). However, despite an infinity of attractors, only a few of them manage to attract the system towards itself. Therefore, a limited diversity phenomenon can be conceived of such attractors as well. In terms of complexity, configurations (paths/terms) within a truth table are equivalent of attractors that have managed to attract some cases (as complex systems) towards themselves. Logical remainders are in fact those attractors that failed to attract any case. Now, then, a

thought provoking question can be as follows: why are some attractors (configurations) across the coordinate so attractive for the cases? This is a question that the present study tries to answer for cancer screening behaviour by use of a QCA analysis.



(The dots in the figure represent some of the configurations (attractors) that system could dispose towards. The dots on the top of ridges represent the most attractive attractors)

Figure 13. A schematic illustration of attractors (configurations) of a complex system

Considering the patterns of clustering of cases in a truth table, one can make an important point here: clustering resonates well with concept of 'limited diversity' in qualitative comparative analysis (QCA). QCA relies on a truth table which lists all the logically possible combinations of causally relevant conditions. In typical application of the truth table approach, researchers find that most cases are captured by a relatively small subset of truth table rows. In other words, a common finding in truth table analysis is that case diversity is profoundly limited. Often, only a minority of the logically possible combinations of conditions can have empirical instances. The examination of limited diversity (the distribution of cases across truth table rows) shows which 'coherencies' are empirically common and which combinations of attributes are uncommon (even impossible).

17. Truth Table Algorithm

This section aims to graphically illustrate all the process of QCA, literally called a truth table algorithm, covered so far from the creation of a data matrix for an interpretation of either necessary (N) or sufficient (S) conditions (solutions) (Figure 14). An interesting point is that all the algorithm steps should be repeated if one is interested in the analysis of necessary and sufficient conditions for negation of the outcome (~Y), as the configurations and the consistency scores for ~Y might be totally different than those for Y.

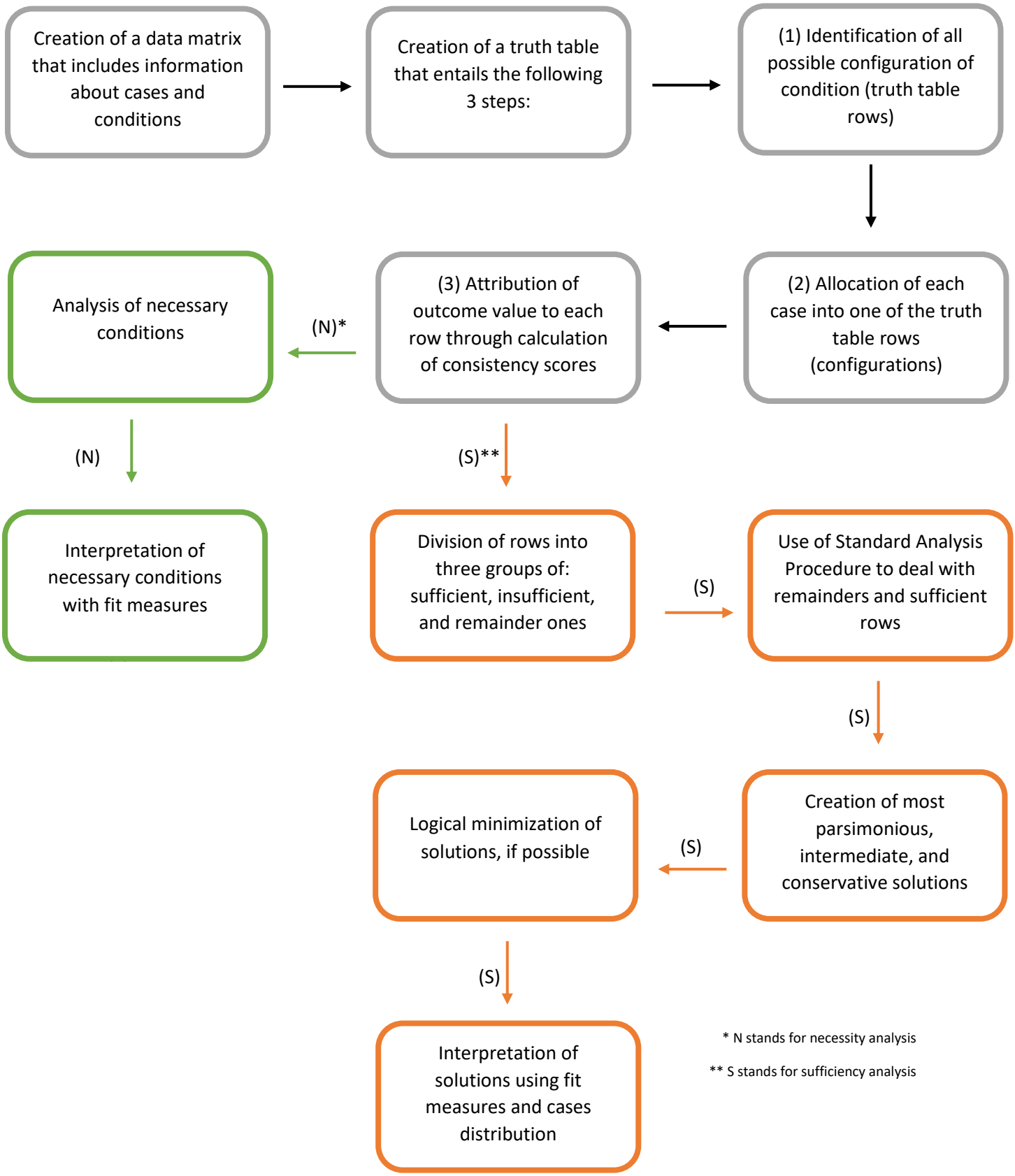


Figure 14. A schematic illustration of truth table algorithm

18. Sampling strategy

Following Emmel's approach to sampling in qualitative (complex) realist-based research (Emmel, 2013), the researcher in this thesis used a "theoretical and purposive" sampling strategy to choose the cases into the study. "Theoretical and purposive" sampling is of unique features that are different from "theoretical" and "purposeful" sampling strategies used, respectively, in grounded theory and other non-realist qualitative research projects. Namely, the sample and its features are shaped by two factors in the theoretical and purposive sampling: (1) theoretical basis and (2) empirical contours of investigation. A researcher steps into a field of study with a theoretical basis as a guide to understand the categories of features that are important to be seen in a sample and also for understanding of a phenomenon. In fact, using that theoretical categories of features, a pre-defined quota of cases from specific parts of a wider population are defined to be sampled. Then, the researcher delves into the context to inductively find and recruit such cases. But, particularities, nuances, possibilities, and difficulties of the context and cases make the researcher to re-think and modify the theoretical categories, features, and pre-defined quotas in a way that the sample takes a new shape. This dialogue and interaction between theory and empirical conditions is of defining features of theoretical and purposive sampling.

This interaction has some implications for a wider population that findings from a sample can be generalized to. To be precise, a theoretical stance that a researcher adopts before sampling would define the ontological and epistemological outlook of that researcher. This outlook, then, would coherently render to research design and choices about whom or what to sample. Therefore, rigour of generalising claims from "theoretical and purposive" sampling depends on abilities of a researcher to describe the wider population from which a sample was drawn. However, although these generalisations (claims) are mapped between theoretical and empirical contours of sampling process, they are theoretical in nature (and not empirical as

seen in stochastic research that have a representative logic). According to Mason, theoretical generalisation claims in a theoretical and purposive sampling strategy can take (one or more of) the five following forms (Mason, 2017). (1) A claim that as findings are coming from "typical cases" from a wider population, so they can be generalized to that wider population (because of typicality of sampled cases). (2) A claim that as sampling focused on specific "social processes" among a sample of people in a context, this can provide an opportunity to generalize the processes to more cases in the wider context. From example, a researcher may reveal roles of some specific explanatory elements in a social process in a sample of cases and then pose some questions about wider resonance of such elements in a wider population that the sample came from. (3) A claim that as a sample is made up of extreme/unusual/pivotal cases, it can improve explanatory power of a relevant theoretical framework that was not considering such cases before. (4) A claim that as sample includes cases that provide rich "comparative knowledge", it can enable a researcher to develop new overarching explanatory propositions. Finally, (5) a claim that as a sample focuses on a particular context, it can show how some processes work in that specific context at large. Moreover, this claim can also lead to cross-contextual generalizations, illustrating the ways contexts shape the social processes.

Theoretical and purposive sampling strategy was used in the present study to choose the required cases that would allow the researcher to deeply investigate screening behaviour in Hull and then theoretically generalize the findings to a wider population. As discussed before, the theoretical basis of this research was a complex configurational stance. Seeing (individual) cases as complex systems made up of configurations of several personal and social conditions (factors), the researcher aimed to understand configurations of conditions that produced colorectal cancer screening behaviour in Hull. This aim was in line with one of the above-mentioned generalization claims about understanding a specific social process (configuration of conditions for screening behaviour) among a sample of cases and the way it can be

generalized to a wider population. Moreover, effects of socioeconomic contexts on screening behaviour (and its inequalities) were of huge importance for the researcher as well. Therefore, the researcher aimed to compare cases from different socioeconomic contexts in the city. This issue was in line with two of above-mentioned generalization claims. First, the claim that a sample includes cases that provide rich "comparative knowledge" about a phenomenon in a way that it can enable a researcher to develop or propose new explanatory propositions which can be generalized to a wider population. Second, the claim that as a sample focuses on a particular context, it can show how some processes (configurations) work in that context at large. This issue can also lead to cross-contextual generalizations, illustrating how context shapes the processes/configurations. To summarize it, the sampling in the present study, informed by a complex realism ontology, was context-specific, comparative, and process (configuration)-focused and can have related generalization claims. Moreover, in order to enrich the process (configuration)-orientedness of the sampling and the study, we used an evidence-informed theory about colorectal cancer screening behaviour (Honein-AbouHaidar et al., 2016), as a guide and prompt, to ease our way into cases' world and to facilitate our conversation with them. This matter could also help us to have a more process-related generalizability to the wider population in Hull. Detailed features of our sampling process are explicated in the following paragraphs.

As the programme for colorectal cancer screening is offered for people aged 60 to 74 years old in the UK, the researcher had to only choose cases from people of this age span. Moreover, the researcher wanted to have variations in the features of the people who could participate in the study. In fact, the pre-defined sampling quota was defined to include cases from both gender and various ethnicities, languages, and nationalities. More importantly, because of the increasing evidence of socioeconomic inequalities in distribution of colorectal cancer screening behaviour, with higher rates of screening among the better-off (Deding et al., 2019), the

researcher aimed to choose cases from two neighbourhoods with highest and lowest deprivation levels in Hull. This matter gave us an ability to compare the differences in configurations of conditions that led to differences in screening behaviour in this two neighbourhoods (contexts) and the city at large. General Physician (GP) practices were the hub of contact with and access to cases in the present study. In fact, two GP practices in the two selected neighbourhoods were contacted to act as access gates into each community and cases. Interestingly, these two practices had the highest and lowest rates of colorectal cancer screening in the city, corresponding to their socioeconomic and deprivation levels. These two neighbourhoods and practices were selected in consultation with department of public health at city council. The selected GP practices were James Alexander Family Practice and Haxby Group Kingswood Surgery, located in the most and least deprived areas of Hull, respectively (Figure 15).

Figure 15. Two GP practices that were chosen as sampling hubs

Department of public health was consulted with as Hull, generally speaking, a relatively deprived city and the researcher wanted to choose the cases who were really different in terms of their socioeconomic status (i.e. most deprived vs. least deprived). However, despite these efforts to stay loyal to the pre-defined sampling quota, contours of the empirical reality in Hull re-shaped the sample. For instance, the researcher failed to have access to cases from other ethnic groups and languages (minorities) and only White British people agreed to participate in the study. This matter would, consequently, limit our generalization power as we can only generalize (i.e. theoretical generalization) the findings to the majorities in the city. This matter should also be borne in mind when trying to compare our findings with studies in other contexts.

19. Data collection

After obtaining ethical permission to conduct the study from the Health Research Authority in NHS (Yorkshire and Humber - Bradford Leeds Research Ethics Committee), the two selected GP practices were approached by the researcher. Both healthcare centres provided a list of all their eligible population, according to the pre-defined sampling quota, that did and did not take part in the screening programme. The researcher then chose a preliminary group of people (aged 60 to 74, from both genders, with and without screening history, from different ethnic origins and languages) from the provided lists. These people were phoned by a healthcare centre staff (a nurse) to invite them for interviews. Some of the people contacted, as above-mentioned, were not happy to take part in the study and declined the invitation. Those who accepted were then contacted by the researcher and the interview time and place were agreed. All the interviews took place in the healthcare centres and the participants kindly agreed to attend the centre. The process of choosing the cases from the provided list and contacting participants was repeated once more time and those who accepted the invitation were interviewed. Eventually, 30 cases (15 from each healthcare centre) were interviewed and the

required data was gathered. A consent form was signed by all the interviewees before the interviews.

The required data was gathered through in-depth semi-structured interviews with participants. Honein and colleagues' conceptual model (Honein-AbouHaidar et al., 2016) was used as a guide to develop the interview guide and questions. The researcher tried to dig into cases' experiences, knowledge, attitudes, beliefs, and narratives of CRC screening during the interviews. The researcher acted as a facilitator and prompter to encourage participants to speak more about their experiences and ideas. The interviews continued until no new data was gathered.

20. Data analysis

All the interviews were recorded (with participants' informed consent) and transcribed verbatim. A thematic content analysis of transcripts was undertaken afterwards. In the next step, the researcher read the transcribed interviews over and over again to elicit the conditions and themes that played a role in participation in colorectal cancer screening. A list of elicited themes (conditions) for each participant was then prepared. Following a QCA framework, the conditions were dichotomized, as 1 indicating the presence of the condition and as 0 indicating the absence of the condition. This way a sheet of numerical data was produced for each participant. These sheets were then transferred into a table, a truth table, to be used in the next QCA steps.

Software R was in the last step used to analyse the truth table, eliciting the configuration of conditions, the necessity and sufficiency of conditions, and the solution terms (most parsimonious, intermediate, and most complex solutions). The analyses in R were repeated for presence and absence of screening behaviour among the chosen cases as follows:

A- Presence of outcome
- 1- Analysis for the disadvantaged people only
- 2- Analysis for the advantaged people only
- 3- Analysis for both groups

B- Absence of outcome (negation)
- 1- Analysis for the disadvantaged people only
- 2- Analysis for the advantaged people only
- 3- Analysis both groups

The results of these analyses are presented in the next chapter. The interview guide and R software syntax used for data analysis are annexed to the end of the thesis.

Results

1- Extraction of conditions

In order to find the conditions that would be used in the CRC screening truth table algorithm, the following steps were taken: (1) verbatim transcription of interviews with 30 cases; (2) reading and coding of transcripts to find the themes; and (3) grouping of themes into the overarching themes. The extracted themes and overarching themes were considered as the conditions to be used in the subsequent analyses. The systematic literature review was used as a guide in the extraction and grouping of the themes. The themes and the overarching themes that emerged from the analysis and coding of the transcripts are showed in the Table 8, along with notations used in QCA for themes/conditions. If a condition is present/high/positive, the notation is written in upper case (MOTIVATION, AWARENESS, ATTITUDE, LOGISTIC, NOFEAR, NOAVERSION, OUTCOME) and if it is absent/low/negative, it is written in lower case (motivation, awareness, attitude, logistic, nofear, noaversion, outcome). Accordingly, "nofear" and "noaversion" represent presence of fear and aversion and NOFEAR and NOAVERSION represent their absence.

In addition, the researcher decided to use complex solution, rather than the intermediate or most parsimonious types, for the interpretation of results. The reason for this decision lies in the richness of information that complex solution can provide about screening in the present study.

Table 8. Themes and over-arching themes extracted from analysis of transcripts

Themes	Overarching themes	QCA code in R
Screening as a peace of the mind Being proactive and conscious about ones' health Having a close persons with CRC (now or in the past) in social network Encouragement and support provided by the spouse	Motivation to do the test	MOTIVATION
Having a close person with CRC (now or in the past) in social network Other health or life priorities	Lack of motivation to do the test	Motivation
Aversion towards the FOBT (dealing with bowel movement, its squeamishness, and awkwardness of the kit)	Aversion towards the test	noaversion
Convenience and easiness of the test (FOBT) Lack of aversion towards the test (dealing with bowel movement, its squeamishness, and awkwardness of the kit)	Lack of aversion towards the test	NOAVERSION
Awareness of bowel cancer symptoms, screening purpose, indication (lack of symptom), and periodicity	Awareness of screening	AWARENESS
Lack of awareness of bowel cancer symptoms, screening purpose, indication (lack of symptom), and periodicity	Lack of awareness of screening	awareness
High belief in efficacy of the test	Positive attitude towards the test	ATTITUDE
Low belief in efficacy of the test	Negative attitude towards the test	attitude
Possession of logistic facilities to safely use, store, and post the kit back	Presence of logistics	LOGISTICS
Lack of logistic facilities to safely use, store, and post the kit back	Lack of logistics	logistics
Fear of having cancer that can be diagnosed with screening (and the pain and treatment after that)	Cancer fear	nofear
No fear of having cancer that can be diagnosed with screening	No fear of cancer	NOFEAR

The reasons why themes are grouped under specific overarching themes and relevant quotes (from the transcripts) are explained in the following section.

1-1 Motivation

In health promotion literature, motivation is defined as "willingness of a person to participate in health-promoting interventions and to implement recommendations for a healthy lifestyle" (Kirch, 2008). Motivation can emanate from two sources: external and internal. External factors lie in the person's environment and can lead to the behaviour. Internal factors reside within the person and push them to take up the behaviour (Patrick and Williams, 2012). In our study, motivation was defined as a personal willingness to participate in a bowel cancer screening program. Interestingly, there were two internal and external themes that could motivate screening behaviour. The internal motivational themes were peace of mind (provided by screening) and being proactive about one's health. The external themes were spousal encouragement and having someone with CRC screening experience (now or in the past) in the close social circle. Some of the quotes from the participants in this regard are as follows:

"...but personally I want to know the answer. I am taking the test for my peace of mind and if by doing the test it keeps me going for few more years, then yeah will do very happily." **(Female)**

"Well I know you could have stomach cramps and pains, blood in your bowel movement, bloated stomach. If I see one of these problems staying and not going away I will go directly to a doctor. Straight away. I do, I do check for all these problems. To a certain extent I can tell that I am a health and body-conscious person. You know, we all should be, shouldn't we?" **(Female)**

"I pushed my husband to take up the test the moment he became eligible to take it. I pushed him to do it. I made him. I have got this power." **(Female)**

"My friend's father had cancer. Sharon was my friend who I used to work with, emigrated to Australia. Her father in law died of bowel cancer. I did watch him died. Because her husband's dad come over from Australia and I went around with them. Another case was Doreen. Doreen was a colleague I worked with. She got bowel cancer, but she had that cancer 10 years ago, and then she got out clear, but not long after it came back and shred her bowel. So, I have seen quite a few people died of cancer and it really shook me to take some actions to prevent it or catch it early." **(Male)**

1-2 Lack of Motivation

Having a person with colorectal cancer in the social circle and having other social and health-related priorities were categorized under the overarching theme of lack of motivation. Interestingly, having a person with colorectal cancer in the social circle acted as a motivator for some people but as a deterrent for some other. Some of the quotes related to these themes are provided below:

"*Yes, my husband's father died of cancer, bowel cancer. It was awful, really awful. You don't know what he went through…I am taken back when thinking of that. Just to touch the kit or see it, that awful memories come alive and I am away from it."* **(Female)**

"I have some couple of health sufferings right now. I mean, I am suffering from diabetes and severe arthritis and have no time or wish to add something else to my health list. I think it is enough for me and my family, I don't want having them seeing me challenging with another suffering as well." **(Male)**

1-3 Test aversion

Test aversion (or lack of it) was one of the themes/conditions that emerged from the analysis of interviews. Aversion is a feeling of disgust or dislike towards the FOBT. One of the participants, as an example, described the feeling as follows.

"*I do not like messing about with body movements, you know. When I had children, if I had to go to the room and saw my wife changing the nappies, I would walk out. I have a very weak stomach, you know. I cannot play with that stick that is within the test. That is very squeamish, very squeamish.*" **(Male)**

Interestingly, those who had an aversive feeling wished for a different and less unpleasant test. They suggested that there would be a higher chance of screening in society if the current test (FOBT) was changed for a nicer, cleaner, and more acceptable one. For example, one of the participants who had lost her husband due to cancer stated that:

*"I would certainly do the test if it was something nicer, like doing it once and not thrice. Something more hygienic. I mean if it was not touching, you know, playing with, your bowel movement. I would do for sure then. Are they going to change it?"***(Female)**

1-4 Lack of test aversion

On the other hand, some participants reported that they do not have any aversive feelings towards the test and test aversion is not a barrier to doing the test for them. One of the participants, as an example, reported of her lack of aversive feeling as follows.

"*No, no, I had no feeling of squeamishness, no I think it's straightforward you know. The test is good and necessary, I think. Just you have to do it. It might seem disgusting for some people, men particularly, but not for me, not at all."* **(Female)**

1-5 Awareness

In this study, awareness means having information and understanding about bowel cancer symptoms and screening. However, this overarching theme had some sub-themes as follows: awareness of bowel cancer symptoms, awareness of screening purpose, awareness of screening indication (when it is needed), and awareness of its periodicity (timing of screening). However, I would like to elaborate more on awareness of screening indication. Research has shown that a significant number of eligible people don't take up the test as they wrongly think that there should be some cancer symptoms as indications of a need for screening (Holmes-Rovner et al., 2002). This matter has been a challenge for the promotion of screening. Some of the quotes about the awareness sub-themes from the participants are as follows:

"*The symptoms are, if I am right, changing motions, changing the regularity of going to toilet, loss of weight, blood in stools. If they continue for a long time, then you have to be concerned about bowel cancer*." **(Male)**

"*Well, the screening, I guess, looks for blood in your stool and any abnormality or something which can be related to cancer. So, its purpose is to detect cancer early and it would be a better chance of cure.*" **(Female)**

"I had no symptom, pain, blood, whatever, but I heard and read that when I am over 60 I have to care about my bowel health. So, I waited until I got to sixty and went for my nurse and told her I need this test and she told me they will send……" **(Female)**

1-6 Lack of awareness

Lack of information about symptoms of colorectal cancer, screening purpose, screening indication (when it is needed), and screening periodicity (timing of screening) were considered

as sub-themes of the lack of awareness (the over-arching theme). Some of the quotes related to these themes are provided as follows:

"There are times that I feel pain or bloated in my stomach, as if someone is pushing and pulling my stomach, but I don't care. No, I don't know something about bowel (cancer) symptoms, I'm guessing that maybe they might bleed or something like that's, that's all I would know". **(Male)**

"*But, I have never questioned the reason why they are sending it to us. I don't question medical things, I am just grateful that there are such things and you know they can do something for you, you can get screening. We are very fortunate*". **(Female)**

1-7 Attitude

Attitudes are positive or negative evaluations that people make about other people, ideas, events, and objects. In the present study, the attitude was defined as participants' evaluation of the efficacy of the FOBT and its usefulness. Some participants made a positive evaluation of the test and believed that the test was reliable/useful and that taking the test could make a difference to people's lives, although it was not 100% accurate. Conversely, other people made a negative evaluation of the test's efficacy and believed that when a test is not 100% accurate and efficacious, there is no point in taking it up. There were even some cases who had no aversion towards the test, but doubted the test's efficacy and usefulness as it was not 100% sure and therefore rejected doing the test. Some of the quotes about this matter are as follows:

"*I think that it is a good thing. And I am not clumsy doing it, whatsoever. Yeah, I suppose that's just my mind-set, my way of thinking. Plus, it works and though it is not 100% sure, as I read in somewhere and some people might say, but it works and is better than nothing, you know. The test finds the cancer in its dormancy and that is a good thing of a test*". **(Male)**

"*The test is clumsy, not-fit, disgusting. To muddy the waters, it is not a sure test, less than 100%, who knows what percent? But not 100%. Is there any other way to do it, I wonder? The other day I was thinking why they send this when I have not taken it up so far and it is not 100%. I don't like it and wish for something better. When it comes I just put it aside and then dustbin. Is it possible for them to send something better, a better and surer test?*" **(Female)**

1-8 FOBT-related logistic

One of the themes/conditions that emerged in the qualitative analysis of data was FOBT-related logistics. 'Logistics' refers to whether there is a place within the house where the participant can store the FOBT kit easily and accessibly without fear of contamination mess. Some participants, regrettably, stated that they lack such a place and prefer to forget about doing the test altogether. Some of the quotes about logistics are as follows.

"*There is a place in the bathroom that we put it there, I mean the kit. My wife puts it there and no one touches it. It is filthy, but there's at least a place for it, so we don't see it. Maybe some people do not have such a place and that is a barrier*". **(Male)**

"*I do not know. I think I am always frightened of if there is anything. Plus, the way they do it, where you do it and keep it for 3 days, that just, you cannot do it. Even I am not feeling squeamish doing it, I do not have the facilities to keep it. So, where should I put it, I can't just leave it in the bathroom. You can't keep it in the bedroom. I would personally prefer to do it in one day and send it to the doctor's office. I would rather to do it so*". **(Female)**

1-9 Fear of cancer

Fear of developing cancer and of facing its difficult complications (e.g. pain, treatment, etc.) after taking up the screening was one of the themes that surfaced throughout the interviews. Some of the quotes about cancer fear are as follows:

"*As I myself have got a large prostate and I had surgery on that, I would say I was very afraid and frightened that I would develop cancer again after the screening and I would go through that awful therapy process. It is terrifying. This fear and dread, to my mind, is the most important thing in keeping people away from the test. Isn't it?"* **(Male)**

"*The only thing that bothers me about the test is that you do the test and it comes back and it will be more than one year to get another one, and I think well what if you get cancer in between. More frighteningly, the fear that what if the test comes positive is always lurking somewhere in your mind. If it is positive, then you suffer immeasurably. However, I take up the test with no fear, I say let's face it today*". **(Female)**

2- Qualitative Comparative Analysis (QCA)

All the over-arching themes elicited from interview transcripts were considered as conditions to be included in the QCA. However, as inequality in distribution of screening for bowel cancer in Hull was also of interest, economic status was also entered into the QCA as a condition (context). The participants were selected from two neighbourhoods, one with high and one with low economic status. Low and high economic status were coded as 0 and 1 in the QCA, respectively. All the conditions were coded in the same way, 0 for lack of the condition and 1 for presence of the condition. For the outcome, 0 indicated of lack of screening and 1 indicated screening.

3- Descriptive features of participants

3-1 Data matrix

Table 9 illustrates a matrix of data about cases and their status in terms of conditions and outcome. As the table shows, over half of the participants were female (16 people). There was an equal number of people from each neighbourhood (i.e. of high and low economic status).

The participants were aged between 62 and 72 years. More than two thirds, regardless of their socioeconomic status, had a positive attitude towards the test. People of high socioeconomic status fared better in almost all the conditions and the outcome compared to their counterparts of low socioeconomic status.

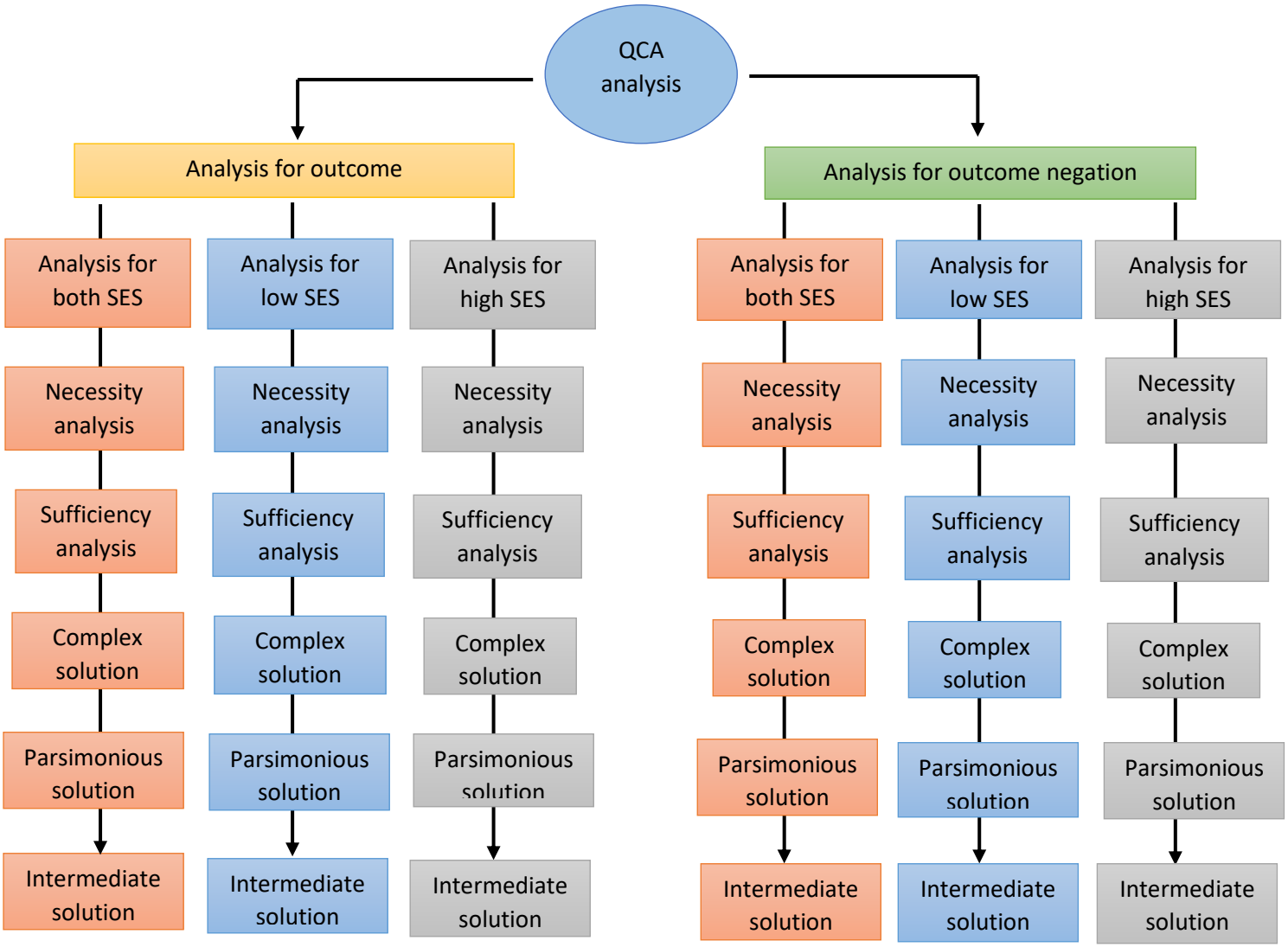
Table 9. A descriptive data matrix for conditions and outcome among participants in Hull

Cases **(low economic status)**	Age	Gender	Motivation	Lack of aversion	Lack of fear	Awareness	Attitude	Logistic	Outcome
1	64	M	1	0	1	1	1	1	1
2	67	F	1	1	0	0	1	1	1
3	62	F	1	1	0	1	1	1	1
4	71	M	1	1	0	1	1	1	1
5	69	M	1	0	0	1	1	0	1
6	62	F	1	0	1	1	1	1	1
7	67	F	1	1	0	1	1	1	1
8	65	F	0	0	0	1	1	0	0
9	70	F	0	0	0	0	0	0	0
10	69	M	0	0	1	1	0	0	0
11	65	F	0	0	0	0	0	0	0
12	67	M	0	0	0	1	0	1	0
13	70	M	0	0	0	1	1	0	0
14	69	M	0	0	0	1	1	0	0
15	63	F	0	1	0	0	0	1	0
Total N of 0	**-**	**-**	**8**	**10**	**12**	**4**	**5**	**7**	**8**
Total N of 1	**-**	**-**	**7**	**5**	**3**	**11**	**10**	**8**	**7**
Cases **(high economic status)**	Age	Gender	Motivation	Lack of aversion	Lack of fear	Awareness	Attitude	Logistic	Outcome
16	68	F	1	1	1	1	1	1	1
17	64	M	0	0	0	0	1	1	0
18	73	F	1	1	1	0	1	1	1
19	68	M	1	1	1	1	1	1	1
20	66	F	1	1	1	0	1	1	1

21	69	M	1	1	0	0	1	1	1
22	68	F	0	0	0	0	0	0	0
23	65	M	1	1	0	1	1	1	1
24	72	F	1	1	0	1	1	1	1
25	67	M	1	1	1	0	1	1	1
26	66	F	1	1	0	1	1	1	1
27	63	M	0	0	0	1	1	1	0
28	65	F	0	0	0	1	0	1	0
29	68	M	1	1	1	1	0	1	1
30	65	F	1	1	1	1	1	1	1
Total N of 0	**-**	**-**	**4**	**4**	**8**	**6**	**3**	**1**	**4**
Total N of 1	**-**	**-**	**11**	**11**	**7**	**9**	**12**	**14**	**11**

The results of crisp-set QCA will be reported in the following sections. Following QCA instructions, analyses were conducted separately for the outcome (screening) and its negation (lack of screening). Therefore, the results will be reported in two broad categories: one for the outcome and another for the outcome negation. In each category three distinct analyses were undertaken: (1) analysis for both socioeconomic groups (together), (2) analysis for low socioeconomic group only, and (3) analysis for high socioeconomic group only. The following steps were taken in order in each distinct QCA analysis: (a) necessity analysis, (b) construction of truth table, and (c) sufficiency analysis (which included the following 3 consecutive analyses: complex solution analysis, most parsimonious solution analysis, and intermediate solution analysis). The analysis process is illustrated in the following figure (Figure 16).

Figure 16. A schematic illustration of 6 distinct QCA analyses undertaken in this study



4- Analysis for both SES groups

4-1 Analysis for outcome

In this section, the results of analysis for the outcome (when outcome is present) when both SES groups are considered are reported.

4-1-1 Necessity analysis for outcome

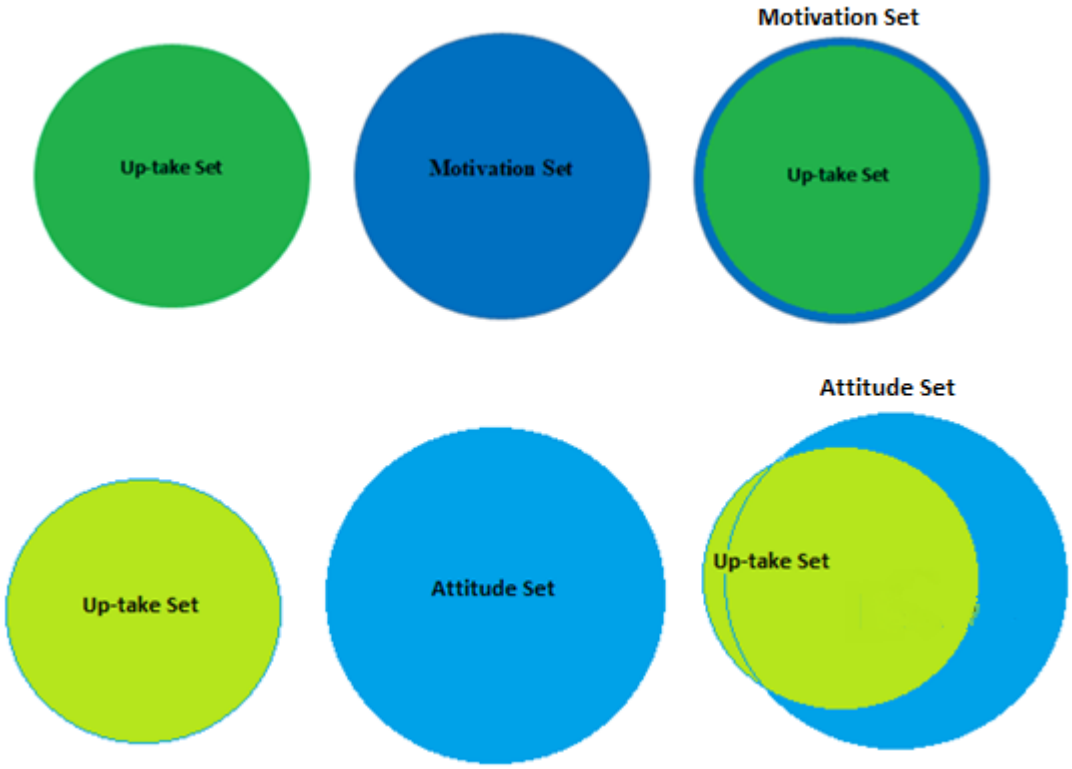
The data matrix for this part of the analysis is in table 9 above. The findings of the necessity analysis (for conditions and their various combinations) are reported below (table 10). Considering high values of necessity parameters, the threshold for consistency was set at 90% in the present study.

Table 10. Necessity analysis for outcome when both SES groups are considered in Hull

Condition(s)	Consistency value	Coverage value
MOTIVATION	1.00	1.00
ATITUDE	0.944	0.773
LOGISTIC	0.944	0.773
MOTIVATION + ATITIUDE	0.944	1.00
MOTIVATION + LOGISTIC	0.944	1.00
NOAVERSION+NOFEAR	0.944	0.895

As table 10 shows, presence of motivation, positive attitude, and availability of logistical facilities are necessary conditions for the presence of outcome, i.e. screening for colorectal cancer in Hull. Necessity of a condition means that whenever the outcome is present, the condition "must" be among the conditions that led to the outcome. Considering consistency and coverage values, the evidence shows that these conditions are supersets of the outcome and such a relation is not trivial (is very strong). The following figure (figure 17) schematically illustrates the necessity of motivation and positive attitude for the outcome**.**

Figure 17. Schematic illustration of superset relations of motivation and attitude with screening when both SES groups are considered



As this figure illustrates, motivation is a full superset of the screening outcome in Hull and significantly necessary for the outcome. However, attitude is only a partial superset of the screening outcome and less significantly necessary. In other words, there can be cases where positive attitude is absent, but the outcome is present. Interestingly, neither low nor high socioeconomic status, as the context, was necessary for emergence of the outcome among the cases.

4-1-2 Truth table for outcome

The truth table (at this stage of analysis when two socioeconomic groups are considered) is illustrated below. Considering the number of conditions (7 conditions) and the truth table formula 2k, there could be 128 different configurations (combinations) of conditions. However,

as the table shows, only 18 configurations appeared in reality, i.e. were populated by cases, and the remaining 110 rows were logical remainders. Because of the constraints, only the 18 rows with cases are shown in the following table (table 11).

Table 11. Truth table for the outcome when two socioeconomic groups are considered in Hull

Configuration	SES	Motivation	Lack of aversion	Lack of fear	Awareness	Attitude	Logistic	outcome	No	consistency	Cases
1	0	1	1	0	1	1	1	1	3	1.00	3,4,7
2	1	1	1	0	1	1	1	1	3	1.00	23, 24,26
3	1	1	1	1	0	1	1	1	3	1.00	18,20,25
4	1	1	1	1	1	1	1	1	3	1.00	16,19,30
5	0	1	0	1	1	1	1	1	2	1.00	1,6
6	0	1	0	0	1	1	0	1	1	1.00	5
7	0	1	1	0	0	1	1	1	1	1.00	2
8	1	1	1	0	0	1	1	1	1	1.00	21
9	1	1	1	1	1	0	1	1	1	1.00	29
10	0	0	0	0	1	1	0	0	3	1.00	8,13,14
11	0	0	0	0	0	0	0	0	2	0.00	9,11
12	0	0	0	0	1	0	1	0	1	0.00	12
13	0	0	0	1	1	0	0	0	1	0.00	10
14	0	0	1	0	0	0	1	0	1	0.00	15
15	1	0	0	0	0	0	0	0	1	0.00	22
16	1	0	0	0	1	1	1	0	1	0.00	27
17	1	0	0	0	1	0	1	0	1	0.00	28
18	1	0	0	0	0	1	1	0	1	0.00	17

Comparison of cases within each configuration in the data matrix shows that there is no contradictory row within the truth table, i.e. there is no configuration with cases that differ in

terms of their outcome status. This fact, which supports the validity of the truth table, may be due to the in-depth knowledge of cases that was obtained by doing semi-structured interviews.

4-1-3 Sufficiency analysis for outcome

In the following section, an analysis of the sufficiency of the conditions and their configurations within the truth table is reported. As there was no contradictory row, all the configurations with high consistency value (value= 1.00) were entered into the sufficiency analysis and no modification (to obviate the contradictions) was needed. This also applies to all analyses conducted and reported in the next sections of this chapter. Results of the sufficiency analysis are reported for complex, parsimonious, and intermediate solutions.

4-1-4 Complex solution for outcome

The complex solution is produced without including any logical remainder in the minimization process. The complex solution in the present study is as follows:

MOTIVIATION*NOAVERSION*nofear*ATTITUDE*LOGISTIC +
SES*MOTIVATION*NOAVERSION*ATTITUDE*LOGISTIC +
SES*MOTIVATION*NOAVERSION*NOFEAR*AWARENESS*LOGISTIC +
ses*MOTIVATION*noaversion*nofear*AWARENESS*ATTITUDE*logistic +
ses*MOTIVATION*noaversion*NOFEAR*AWARENESS*ATTITUDE*LOGISTIC <=> **OUTCOME**

Each component of the complex solution has its own features, covered in the following table. Although all the components of the solution had a high consistency value, as the table shows, the first two configurations had the highest coverage (raw and unique) scores, meaning that these two configurations of conditions can explain more than 90 percent of observed cases. In complex systems terms, these two configurations are the most attractive attractors across a phase-space coordinate. Interestingly, 7 cases (16, 19, 21, 23, 24, 26, 30) could inhabit the first three configurations simultaneously, pointing to the equifinality principle of configurational

analysis. The second configuration had the highest score for the raw coverage value, meaning that this specific configuration can be inhabited by more cases and is the most attractive attractor. However, the coverage score was not high for the remaining configurations, indicating that although the evidence shows that they are sufficient for the outcome, each of these configurations is only trivially sufficient for the outcome (table 12).

Table 12. Complex solutions for outcome when both high and low socioeconomic groups are considered

Configuration	Consistency value	Raw coverage	Unique coverage	Cases
MOTIVATION*NOAVERSION*nofear*ATTITUDE*LOGISTIC	1.000	0.444	0.222	2,3,4,7,21 ,23,24,26
SES*MOTIVATION*NOAVERSION*ATTITUDE*LOGISTIC	1.000	0.556	0.167	21,23,24, 26,18, 20,25,16, 19,30
SES*MOTIVATION*NOAVERSION*NOFEAR*AWARENESS*LOGISTIC	1.000	0.222	0.056	29,16,19, 30
ses*MOTIVATION*noaversion*nofear*AWARENESS*ATTITUDE*logistic	1.000	0.056	0.056	5
ses*MOTIVATION*noaversion*NOFEAR*AWARENESS*ATTITUDE*LOGISTIC	1.000	0.111	0.111	1,6
Complex solution	1.000	1.000	-	-

Analytically speaking, as well as the conjunctural principle of configurational causality in these complex solutions, INUS causal conditions, which are defining features of qualitative research, are also present here. For instance, we can take the positive attitude (ATTITUDE) which is present is almost all of the solutions. It is an insufficient (as it needs to sit with other conditions to bring about the outcome) but necessary (necessity analysis in the previous section) condition for the outcome. However, it sits within configurations that are sufficient but unnecessary for the outcome. Interestingly, such INUS causal conditions are present in almost all the sufficiency analyses reported in the next sections as well.

4-1-5 Parsimonious solution for outcome

Parsimonious solution is produced when all of the logical remainders, rows without enough cases, are included (as counterfactuals) in the minimization process. The result of the minimization process at this stage led to the following most parsimonious solution (table 13):

MOTIVATION <=> **OUTCOME**

Table 13. Parsimonious solutions for outcome when both socioeconomic groups are considered in Hull

Configuration	Consistency value	Raw coverage	Unique coverage
MOTIVATION	1.00	1.00	1.00

Interestingly, the presence of motivation stood out as the most important condition that can lead to emergence of outcome after the minimization of the parsimonious solution. Moreover, consistency and coverage values show that motivation is significantly and fully sufficient for the presence of outcome, i.e. whenever motivation to do the test is present for a case, the presence of outcome is logically and certainly expected and observed. This shows the importance of motivation for screening for colorectal cancer in Hull, as it is both sufficient and necessary for the outcome.

4-1-6 Intermediate solution for outcome

Intermediate solution stands between parsimonious and complex solutions. Accordingly, in using logical remainders for production of intermediate solution, direct expectations are used. Direct expectations are judgements about relations between conditions and the outcome in logical remainders according to practical and theoretical knowledge. In the present study, the following relationships between the conditions and the outcome were considered. Lack of fear, lack of aversion, awareness, positive attitude, high motivation, high SES, and availability of

logistic facilities all lead to colorectal cancer screening. The produced intermediate solution was as follows (table 14):

MOTIVIVATION*AWARENESS*ATTITUDE +

MOTIVATION*NOAVERSION*ATTITUDE*LOGISTIC +

SES*MOTIVATION*NOAVERSION*NOFEAR*AWARENESS*LOGISTIC <=> **OUTCOME**

Table 14. Intermediate solutions when both high and low socioeconomic groups are considered

Configuration	Consistency value	Raw coverage	Unique coverage
MOTIVATION*AWARENESS*ATTITUDE	1.00	0.667	0.167
MOTIVATION*NOAVERSION*ATTITUDE*LOGISTIC	1.00	0.778	0.278
SES*MOTIVATION*NOAVERSION*NOFEAR*AWARENESS*LOGISTIC	1.00	0.222	0.056
Intermediate solution	1.00	1.00	1.00

As the table shows, there are three paths or configurations that can lead to screening for colorectal cancer. All three configurations are fully sufficient for the outcome, but considering the coverage values, the last is trivially important. The second configuration comprising of "MOTIVATION*NOAVERSION*ATTITUDE*LOGISTIC" is the most common and important way for the outcome to emerge. In fact, when these conditions come together, there is a high chance that screening will happen. Interestingly, high socioeconomic status is not evidentially very important for the emergence of screening behaviour.

4-2 Analysis for negation of outcome

In complex systems and QCA, outcome and its negation may need different configurations of conditions to show up (asymmetry principle). Therefore, there are always two analyses in QCA, one for the outcome and another for its negation. The result of QCA for negation of the outcome when both socioeconomic groups are considered is shown below.

4-2-1 Necessity analysis for outcome negation

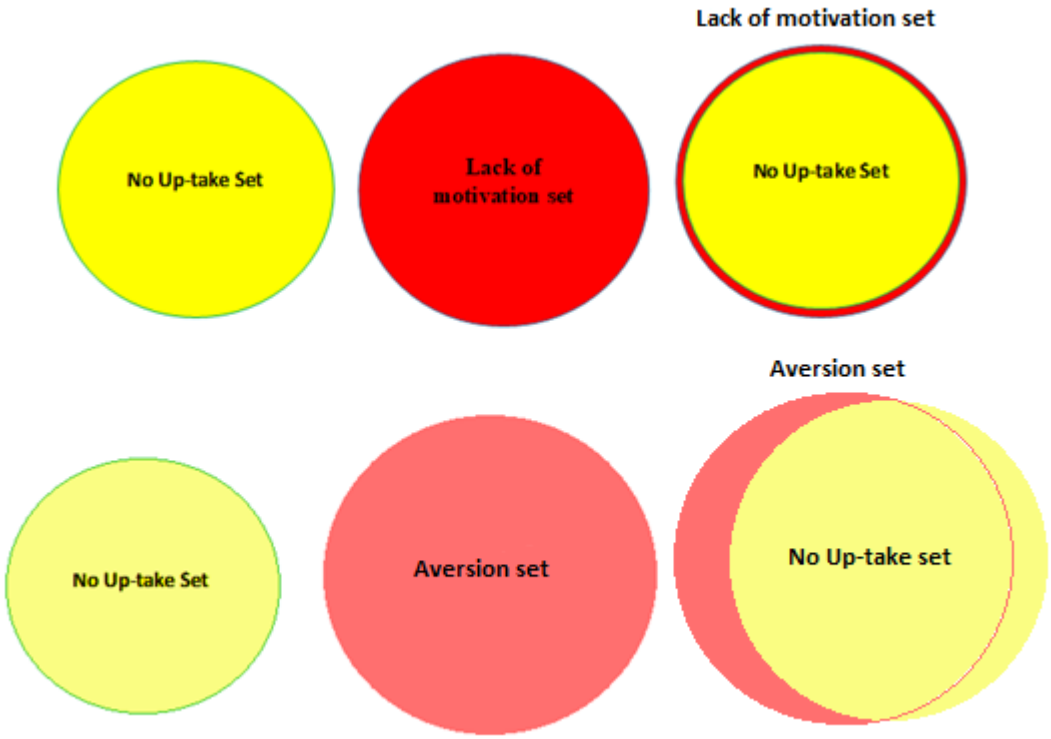
The data matrix (table 9) for the analysis does not differ between QCA analyses (QCA for the outcome and for the outcome negation). The following table (table 15) illustrates the results of necessity analysis for negation of the outcome in both groups.

Table 15. Necessity analysis for outcome negation when two SES groups are considered

Condition(s)	Consistency value	Coverage value
Motivation	1.00	1.00
no-aversion	0.917	0.786
motivation*no-aversion	0.917	1.00
motivation*fear	0.917	1.00

As the table shows, lack of motivation, aversion, and their combination with fear of cancer are necessary conditions for lack of screening (figure 18). Consistency and coverage values show that these two conditions are necessary for lack of screening, and the relationship between them and lack of screening is not trivial.

Figure 18. Schematic illustration of superset relations between motivation, aversion, and not-screening



AAs the figure shows, lack of motivation is a full superset of lack of screening behaviour. Therefore, lack of motivation is significantly necessary for the outcome negation, i.e. there are no cases in which we see lack of screening where lack of motivation cannot be found. On the other hand, aversion is not a full superset of lack of screening, indicating that there can be cases in which we see lack of screening but no trace of aversion towards the test.

4-2-2 Truth table for outcome negation

In the following, the truth table (table 16) for negation of the outcome is illustrated. Interestingly, likewise outcome truth table (table 11), 18 configurations are populated by cases and 110 rows are logical remainders.

Table 16. Truth table for outcome negation when both SES groups are considered in Hull

Configuration (s)	SES	Motivation	Lack of aversion	Lack of fear	Awareness	Attitude	Logistic	outcome	No	consistency	Case
1	0	0	0	0	1	1	0	1	3	1.00	8,13, 14
2	0	0	0	1	1	0	0	1	1	1.00	10
3	0	0	0	0	0	0	0	1	1	1.00	9,11
4	0	0	0	0	1	0	1	1	1	1.00	12
5	0	0	1	0	0	0	1	1	1	1.00	15
6	1	0	0	0	0	0	0	1	1	1.00	22
7	1	0	0	0	1	1	1	1	1	1.00	27
8	1	0	0	0	1	0	1	1	1	1.00	28
9	1	0	0	0	0	1	1	1	1	1.00	17
10	0	1	1	0	1	1	1	0	3	0.00	3,4,7
11	1	1	1	0	1	1	1	0	3	0.00	23,24,26
12	1	1	1	1	0	1	1	0	3	0.00	18,20,25
13	1	1	1	1	1	1	1	0	3	0.00	16,19,30
14	0	1	0	1	1	1	1	0	2	0.00	1,6
15	0	1	0	0	1	1	0	0	1	0.00	5
16	0	1	1	0	0	1	1	0	1	0.00	2
17	1	1	1	0	0	1	1	0	1	0.00	21
18	1	1	1	1	1	0	1	0	1	0.00	29

4-2-3 Complex solution for outcome negation

To summarize the truth table and determine which configurations of conditions lead to negation of the outcome (no screening) when both SES groups are considered, the following complex solution was produced (table 17):

motivation*noaversion*nofear*awareness*attitude*logistic +

motivation*noaversion*nofear*AWARENESS*attitude*LOGISTIC +

SES*motivation*noaversion*nofear*ATTITUDE*LOGISTIC +

ses*motivation*noaversion*nofear*AWARENESS*ATTITUDE*logistic +

ses*motivation*noaversion*NOFEAR*AWARENESS*attitude*logistic +

ses*motivation*NOAVERSION*nofear*awareness*attitude*LOGISTIC <=> **outcome**

Table 17. Complex solutions for outcome negation when both SES groups are considered

Configuration(s)	Consistency value	Raw coverage	Unique coverage	Cases
motivation*noaversion*nofear*awareness*attitude*logistic	1.000	0.250	0.250	9, 11,22
motivation*noaversion*nofear*AWARENESS*attitude*LOGISTIC	1.000	0.167	0.167	12,28
SES*motivation*noaversion*nofear*ATTITUDE*LOGISTIC	1.000	0.167	0.167	17,27
ses*motivation*noaversion*nofear*AWARENESS*ATTITUDE*logistic	1.000	0.250	0.250	8,13,14
ses*motivation*noaversion*NOFEAR*AWARENESS*attitude*logistic	1.000	0.083	0.083	10
ses*motivation*NOAVERSION*nofear*awareness*attitude*LOGISTIC	1.000	0.083	0.083	15
Complex solution	1.000	1.000	-	-

As the solution and table show, there are 6 configurations of conditions that can lead to lack of screening. However, although all of the configurations are fully sufficient for negation of the outcome, coverage scores show that they are trivially important, at least evidentially, and are not populated by a significant number of cases.

4-2-4 Parsimonious solution for outcome negation

After introducing all the logical remainders into the minimization process and doing a counterfactual analysis, the following parsimonious solution was produced (table 18):

motivation <=> **outcome**

Table 18. Parsimonious solutions for outcome negation when both SES groups are considered

Configuration (s)	Consistency value	Coverage value
motivation	1.00	1.00

As the table shows, lack of motivation is the most important factor in terms of not taking up screening. In fact, lack of motivation is a sufficient condition for not taking up the colorectal cancer screening and such a set relation is not trivial. Moreover, considering the necessity analysis, lack of motivation is both sufficient and necessary for the outcome negation.

4-2-5 Intermediate solution for outcome negation

Using directional expectations about the relationship between conditions and negation of the outcome within logical remainders, the intermediate solution term was produced. Based on theories and on the evidence, it was assumed that presence of fear, aversion towards the test, low awareness, negative attitude, low motivation, low SES, and lack of logistic facilities all lead to lack of screening for colorectal cancer. The produced intermediate solution, then, was as follows (table 19):

motivation <=> **outcome**

Table 19. Intermediate solutions for outcome negation when both SES groups are considered

Configuration (s)	Consistency value	Raw coverage	Unique coverage
Motivation	1.00	1.00	1.00

As the table shows, the intermediate solution is similar to the parsimonious solution, showing that low motivation is sufficient for lack of screening. Considering necessity and sufficiency analysis results, one can say that lack of motivation would be the most important and significant determinant (fully necessary and sufficient) of lack of screening, if all the configurations could show up in reality as expected.

5- Analysis for low socioeconomic group only

5-1 Analysis for outcome

In the following section, the QCA results will be presented for two socioeconomic groups separately, beginning first with the low socioeconomic status group.

5-1-1 Data matrix

The following table (table 20) shows the participants' status in terms of the conditions and the outcome when all participants are from poorer parts of Hull.

Table 20. Data matrix for participants coming from poorer parts of Hull

Cases **(low economic status)**	Age	Gender	Motivation	Lack of aversion	Lack of fear	Awareness	Attitude	Logistic	Outcome
1	64	M	1	0	1	1	1	1	1
2	67	F	1	1	0	0	1	1	1
3	62	F	1	1	0	1	1	1	1
4	71	M	1	1	0	1	1	1	1
5	69	M	1	0	0	1	1	0	1
6	62	F	1	0	1	1	1	1	1
7	67	F	1	1	0	1	1	1	1
8	65	F	0	0	0	1	1	0	0
9	70	F	0	0	0	0	0	0	0
10	69	M	0	0	1	1	0	0	0
11	65	F	0	0	0	0	0	0	0
12	67	M	0	0	0	1	0	1	0
13	70	M	0	0	0	1	1	0	0
14	69	M	0	0	0	1	1	0	0
15	63	F	0	1	0	0	0	1	0
Total N of 0	**-**	**-**	**8**	**10**	**12**	**4**	**5**	**7**	**8**
Total N of 1	**-**	**-**	**7**	**5**	**3**	**11**	**10**	**8**	**7**

As the table shows, lack of motivation, aversion towards the test, and fear of cancer were relatively higher among the people of lower SES in Hull. On the other hand, attitude and awareness were relatively positive among this group in Hull.

5-1-2 Necessity analysis for the outcome

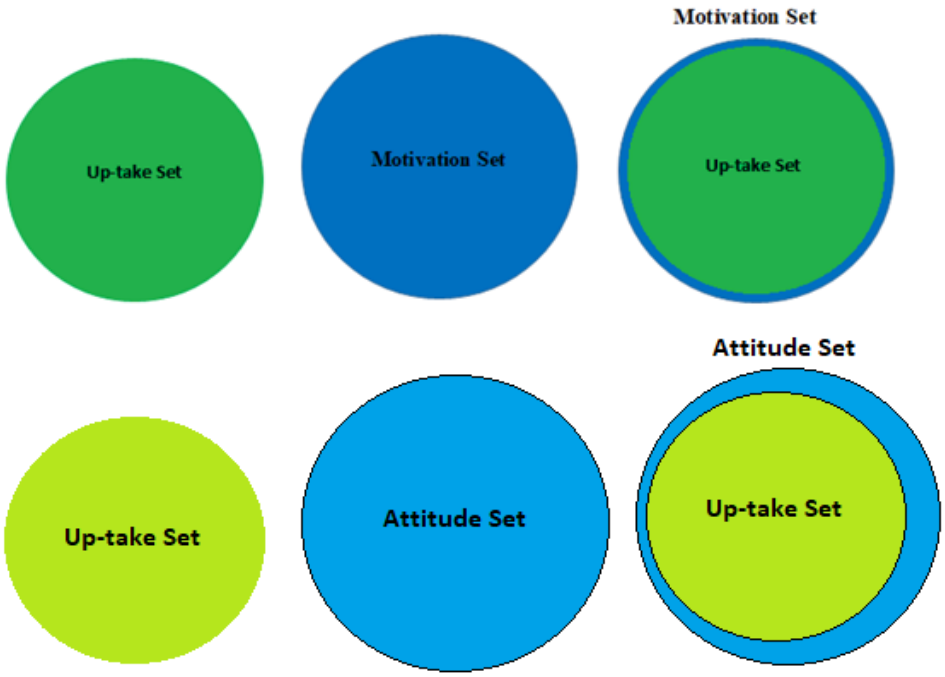
The following table (table 21) illustrates the necessity analysis results for the outcome among people of low SES in Hull.

Table 21. Necessity analysis for the outcome in the lower SES group

Condition(s)	Consistency value	Coverage value
MOTIVATION	1.000	1.000
ATTITUDE	1.000	0.700
MOTIVATION*ATTITUDE	1.000	1.000

As the table shows, high motivation and positive attitude are two of the main factors that lead to screening for colorectal cancer among people of lower socioeconomic status. In fact, they are necessary for screening and their relation with screening uptake is not trivial evidentially (is strong). Figure 19 schematically illustrates the superset relation mentioned above.

Figure 19. Schematic illustration of superset relations between motivation, attitude, and not-screening



As the figure shows, both motivation and attitude are full supersets (necessary) of bowel screening, indicating that whenever one sees the outcome in a case, motivation and positive attitude are present and contributing there.

5-1-3 Truth table for the outcome

The truth table (when low socioeconomic group is considered) is illustrated below. Considering the number of conditions (6 conditions) and the truth table formula 2k, there could be 64 different configurations (combinations) of conditions. However, as the table shows, only 9 rows are populated by cases and the rest of the rows are logical remainders.

Table 22. Truth table for the outcome when only low socioeconomic group is considered

Configuration (s)	Motivation	Lack of aversion	Lack of fear	Awareness	Attitude	Logistic	outcome	No	consistency	Case
1	1	1	0	1	1	1	1	3	1.00	3,4,7
2	1	0	1	1	1	1	1	2	1.00	1, 6
3	1	0	0	1	1	0	1	1	1.00	5
4	1	1	0	0	1	1	1	1	1.00	2
5	0	0	0	1	1	0	0	3	0.00	8,13,14
6	1	0	0	0	0	0	0	2	0.00	9,11
7	0	0	0	1	0	1	0	1	0.00	12
8	0	0	1	1	0	0	0	1	0.00	10
9	0	1	0	0	0	1	0	1	0.00	15

To summarize the information within the truth table, a minimization process was followed that led to the following solutions.

5-1-4 Complex solution for the outcome

Using no logical remainders, the following complex solution (table 23) was produced out of the truth table for the outcome when only people of lower SES in Hull are considered.

MOTIVATION*NOAVERSION*nofear*ATTITUDE*LOGISTIC +

MOTIVATION*noaversion*nofear*AWARENESS*ATTITUDE*logistic +

MOTIV*noaver*NOFEAR*AWARENESS*ATTITUDE*LOGISTIC <=> **OUTCOME**

Table 23. Complex solution for outcome among the low SES group in Hull

Configuration(s)	Consistency value	Raw coverage	Unique coverage	Cases
MOTIVATION*NOAVERSION*nofear*ATTITUDE*LOGISTIC	1.00	0.571	0.571	2,3,4,7
MOTIVATION*noaversion*nofear*AWARENESS*ATTITUDE*logistic	1.00	0.143	0.143	5
MOTIV*noaver*NOFEAR*AWARENESS*ATTITUDE*LOGISTIC	1.00	0.286	0.286	1,6
Complex solution	1.00	1.00	1.00	-

As the table shows, there are there different configurations of conditions that can lead to colorectal cancer screening among people of low socioeconomic status in Hull. As can be seen, all the configurations are fully subsets of the outcome, but the coverage score is low which shows that, although they are sufficient, the evidence is trivially important (the set relations are not strong).

5-1-5 Parsimonious solution for the outcome

HUsing all the logical remainders to produce the most parsimonious solution for the outcome among the low SES group in Hull, the following solution was produced (table 24):

MOTIVATION <=> **OUTCOME**

Table 24. Most parsimonious solution for the outcome in the low SES group in Hull

Configuration (s)	Consistency value	Coverage value
MOTIVATION	1.00	1.00

The table shows that, if all the logical remainders were to be show up in reality, (high level of) motivation would be a full subset of the outcome among people of lower socioeconomic status in Hull, and such a relationship (the sufficiency relationship) would be strong.

5-1-6 Intermediate solution for the outcome

Inclusion of logical remainders based on directional expectation (similar to the expectations applied for the analysis of both SES groups) led to the following intermediate solution (table 25):

MOTIVATION*AWARENESS*ATTITUDE +

MOTIVATION*NOAVERSION*ATTITUDE*LOGISTIC <=> **OUTCOME**

Table 25. Intermediate solution for the outcome among people of low SES group in Hull

Configuration (s)	Consistency value	Raw coverage	Unique coverage
MOTIVATION*AWARENESS*ATTITUDE	1.000	0.857	0.429
MOTIVATION*NOAVERSION*ATTITUDE*LOGISTIC	1.000	0.571	0.143
Intermediate solution	1.00	1.00	1.00

As the table shows, there are two configurations that are sufficient to produce the outcome among participants with low socioeconomic status in Hull when direct expectations are used. However, the first configuration (MOTIVATION*AWARENESS*ATTITUDE) is evidently the most important configuration as it is a full subset of the outcome and such a set relation is significantly important.

5-2 Analysis for outcome negation

After doing the QCA for the outcome among people of lower SES in Hull, now analysis should be repeated for negation of the outcome among this group as well.

5-2-1 Necessity analysis for outcome negation

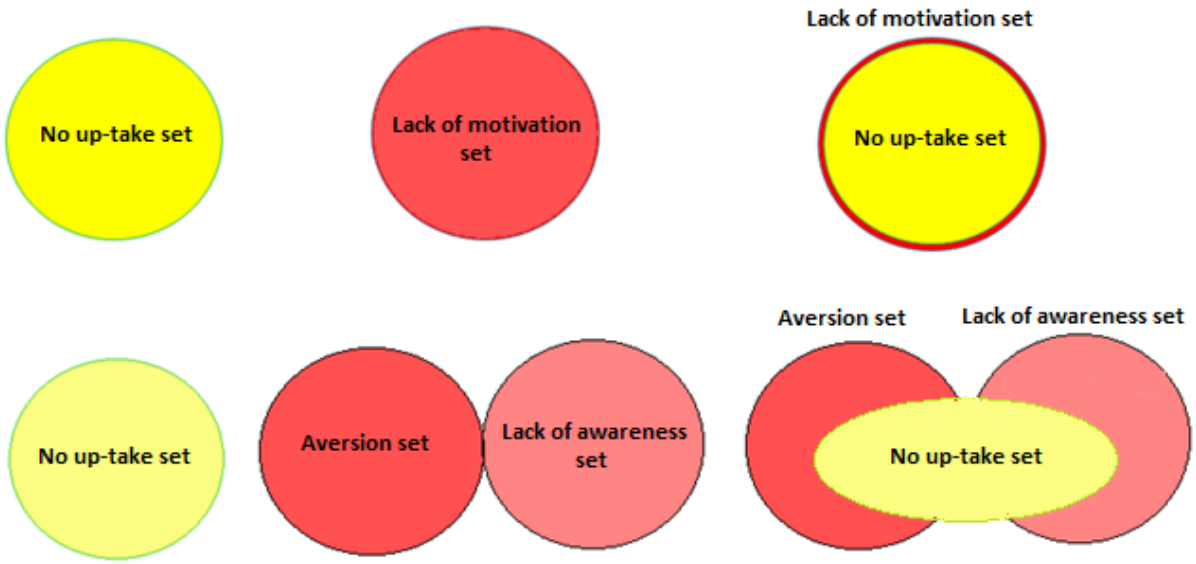
The result of a necessity analysis for negation of the outcome (not doing the screening test) among poor people in Hull is reported below (table 26).

Table 26. Necessity analysis for outcome negation among poor people in Hull

Configuration (s)	Consistency value	Coverage value
Motivation	1.00	1.00
noaversion+awareness	1.00	0.667
noaversion+attitude	1.00	0.727
nofear+attitude	1.00	0.615
nofear+logistic	1.00	0.615
attitude+logistic	1.00	0.615

As the table shows, 6 configurations are necessary for lack of screening among people of lower socioeconomic status in Hull. Lack of motivation is the most important condition, as it is fully a superset of the outcome and is significantly important evidentially, considering the consistency and coverage values. The five remaining configurations are also fully supersets of the negation of the outcome, considering consistency values, but their coverage values show that they are not as important as lack of motivation for emergence of the outcome negation. The following figure (figure 20) schematically illustrates the above-mentioned relationships.

Figure 20. Schematic illustration of superset relations of lack of motivation, aversion, and lack of awareness with outcome negation among low SES people in Hull



As the figure shows, lack of motivation is a full superset of lack of screening, indicating a strong necessary relationship. However, such a strong relationship is not seen for the intersection of aversion and lack of awareness. In fact, around 66% of outcome negation cases are covered by this intersection. In other words, there are some cases in reality who do not take up screening, but who are not aversive towards the test and whose information is not low.

5-2-2 Truth table for outcome negation

The following table represents the truth table for negation of the outcome among people of lower socioeconomic status in Hull.

Table 27. Truth table for negation of the outcome among lower SES group

Configuration (s)	Motivation	Lack of aversion	Lack of fear	Awareness	Attitude	Logistic	outcome	No	consistency	Case
1	0	0	0	1	1	0	1	3	1.00	8,13,14
2	0	0	0	0	0	0	1	1	1.00	9,11
3	0	0	0	1	0	1	1	1	1.00	12
4	0	0	1	1	0	0	1	1	1.00	10
5	0	1	0	0	0	1	1	1	1.00	15
6	1	0	1	1	1	1	1	0	1.00	1,6
7	1	0	0	1	1	0	0	1	1.00	5
8	1	1	0	1	1	1	0	3	0.00	3,4,7
9	1	1	0	0	1	1	0	1	0.00	2

As the table shows, there are 9 rows out of 64 possible rows that accommodate some cases. To summarize the information in the truth table, a logical minimization process was undertaken.

5-2-3 Complex solution for outcome negation

The complex solution, which is produced when only truth table rows with high sufficiency scores are considered, is as follows (logical remainders are excluded) (table 28).

Table 28. Complex solution for outcome negation among people of low SES in Hull

Configuration(s)	Consistency value	Raw coverage	Unique coverage	Cases
motivation*noaversion*nofear*awareness*attitude*logistic	1.00	0.250	0.250	9; 11
motivation*noaversion*nofear*AWARENESS*attitude*LOGISTIC	1.000	0.125	0.125	12
motivation*noaversion *nofear*AWARENESS*ATTITUDE*logistic	1.000	0.375	0.375	8,13,14
motivation*noaversion*NOFEAR*AWARENESS*attitude*logistic	1.000	0.125	0.125	10
motivation*NOAVERSION*nofear*awareness*attitude*LOGISTIC	1.000	0.125	0.125	15
Complex solution	1.00	1.00	-	-

As the table shows, there are five configurations that can lead to negation of outcome among people of lower SES in Hull. All the configurations are full subsets of the outcome negation, but as the coverage scores show, they are trivially important and are only a small subset of the negation of outcome, evidentially (the sufficiency relations are not strong).

5-2-4 Parsimonious solution for outcome negation

If all logical remainders are included in the minimization process, the parsimonious solution will be produced. The parsimonious solution for the outcome negation among people of lower SES in Hull was as follows (table 29).

motivation <=> **outcome**

Table 29. Parsimonious solution for outcome negation among people of low SES in Hull

Configuration (s)	Consistency value	Coverage value
Motivation	1.00	1.00

As the table shows, if all the remainders could show up in reality, lack of motivation would be a sufficient condition for the negation of outcome among people of lower SES in Hull, and such a relationship would be significant and strong.

5-2-5 Intermediate solution for outcome negation

Using directional expectations, similar to the expectations that were used for negation of the outcome in two socioeconomic groups, the following intermediate solution was produced for people of low SES in Hull (table 30).

motivation <=> **outcome**

Table 30. Parsimonious solution for outcome negation among people of low SES in Hull

Configuration (s)	Consistency value	Raw coverage	Unique coverage
motivation	1.000	1.000	1

As the table shows, the intermediate solution is similar to the parsimonious solution in showing that motivation is sufficient for lack of screening among people of lower SES in Hull.

6- Analysis for high SES group only

6-1 Analysis for outcome

In the following section, QCA analysis results will be reported for the high SES group only. The analyses begin with the scenario when the outcome is present.

6-1-1 Data matrix

The following table summarizes information about the conditions and the outcome among high-SES participants in Hull.

Table 31. Data matrix for people of higher SES in Hull

Cases **(high economic status)**	Age	Gender	Motivation	Lack of aversion	Lack of fear	Awareness	Attitude	Logistic	Outcome
1	68	F	1	1	1	1	1	1	1
2	64	M	0	0	0	0	1	1	0
3	73	F	1	1	1	0	1	1	1
4	68	M	1	1	1	1	1	1	1
5	66	F	1	1	1	0	1	1	1
6	69	M	1	1	0	0	1	1	1
7	68	F	0	0	0	0	0	0	0
8	65	M	1	1	0	1	1	1	1
9	72	F	1	1	0	1	1	1	1
10	67	M	1	1	1	0	1	1	1
11	66	F	1	1	0	1	1	1	1
12	63	M	0	0	0	1	1	1	0
13	65	F	0	0	0	1	0	1	0
14	68	M	1	1	1	1	0	1	1
15	65	F	1	1	1	1	1	1	1
Total N of 0	**-**	**-**	**4**	**4**	**8**	**6**	**3**	**1**	**4**
Total N of 1	**-**	**-**	**11**	**11**	**7**	**9**	**12**	**14**	**11**

As the table shows, people in the high SES group in Hull fared well in terms of motivation, lack of aversion, awareness, attitude, logistic facilities, and the outcome. However, fear of cancer was relatively high among these people.

6-1-2 Necessity analysis for the outcome

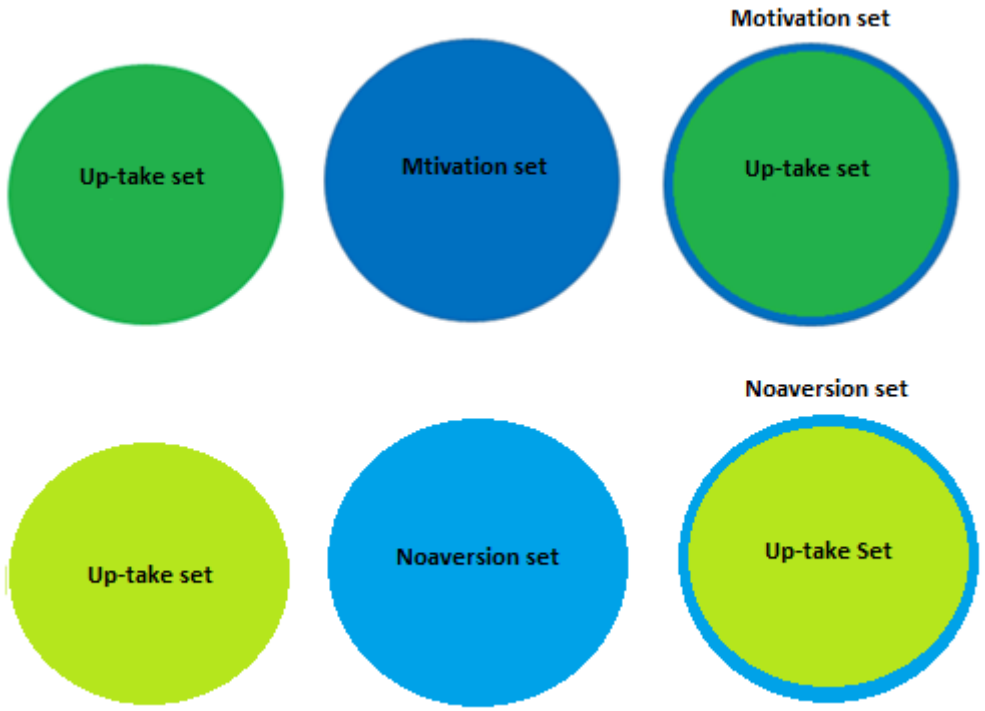
The results of necessity analysis for the outcome among people of high socioeconomic status in Hull is as follows (table 32).

Table 32. Necessity analysis for the outcome among people of high SES in Hull

Configuration (s)	Consistency value	Coverage value
MOTIVATION	1.000	1.000
NOAVERSION	1.000	1.000
ATTITUDE	0.909	0.833
LOGISTIC	1.000	0.786
MOTIVATION*NOAVERSION	1.000	1.000
MOTIVATION*ATTITUDE	0.909	1.000
MOTIVATION*LOGISTIC	1.000	1.000
NOAVERSION*ATTITUDE	0.909	1.000
NOAVERSION*LOGISTIC	1.000	1.000
ATTITUDE*LOGISTIC	0.909	0.833
MOTIVATION*NOAVERSION*ATTITUDE	0.909	1.000
MOTIVATION*NOAVERSION*LOGISTIC	1.000	1.000
MOTIVATION*ATTITUDE*LOGISTIC	0.909	1.000
NOAVERSION*ATTITUDE*LOGISTIC	0.909	1.000
MOTIVATION*NOAVERSION*ATTITUDE*LOGISTIC*	0.909	1.000
NOFEAR+AWARENESS	0.909	0.833

As the table shows, there is a considerable number of conditions (configurations) that are necessary for emergence of the outcome among people of higher SES in Hull. Interestingly, almost all of the conditions are fully superset of the outcome and such set relations are significantly important and strong. The figure 21 provides a better representation of these relationships.

Figure 21. Schematic illustration of subset relations between motivation, lack of aversion, and screening among people of high SES in Hull



As the figure shows, both motivation and lack of aversion are full supersets of screening behaviour, i.e. whenever one sees a rich person taking up the screening in Hull, it is significantly probable that these two conditions (among some others in table 26) are present and contributing.

6-1-3 Truth table for the outcome

The following table illustrates the truth table for the outcome among people of high socioeconomic status in Hull.

Table 33. Truth table for the outcome among people of high SES in Hull

Configuration (s)	Motivation	Lack of aversion	Lack of fear	Awareness	Attitude	Logistic	outcome	No	consistency	Case
1	1	1	0	1	1	1	1	3	1.00	8,9,10
2	1	1	1	0	1	1	1	3	1.00	3,5,10
3	1	1	1	1	1	1	1	3	1.00	1,4,15
4	1	1	0	0	1	1	1	1	1.00	6
5	1	1	1	1	0	1	1	1	1.00	14
6	0	0	0	0	0	0	0	1	0.00	7
7	0	0	0	1	1	1	0	1	0.00	12
8	0	0	0	1	0	1	0	1	0.00	13
9	0	0	0	0	1	1	0	1	0.00	2

As the table shows, there are 9 rows (out of 64) that accommodate some cases in this truth table. However, to summarize the truth table, there should be a minimization process as follows.

6-1-4 Complex solution for the outcome

Complex solution is the result of a minimization process in which no logical remainder is included. The produced complex solution for the above truth table is as follows (table 34).

MOTIVATION*NOAVERSION*ATTITUDE*LOGISTIC +
MOTIVATION*NOAVERSION*NOFEAR*AWARENESS*LOGISTIC <=> **OUTCOME**

Table 34. Complex solution for the outcome among people of high SES in Hull

Configuration(s)	Consistency value	Raw coverage	Unique coverage	Cases
MOTIVATION*NOAVERSION*ATTITUDE*LOGISTIC	1.000	0.909	0.636	6,8,9,11,3, 5,10,1,4,15
MOTIVATION*NOAVERSION*NOFEAR*AWARENESS*LOGISTIC	1.000	0.364	0.091	14,1,4,15
Complex solution	1.00	1.00	-	-

As the table shows, there are two configurations that can lead to screening among rich participants. However, the first configuration is a significant subset of the outcome (fully sufficient, a strong relation) while the second is not.

6-1-5 Parsimonious solution for the outcome

A more parsimonious version of the complex solution is as follows (table 35). Here, all the logical remainders are included in the minimization processes. Interestingly, there are two parsimonious solutions out of the truth table which are as follows:

MOTIVATION <=> **OUTCOME**

NOAVERSION <=> **OUTCOME**

Table 35. Parsimonious solution for the outcome among people of high SES in Hull

Configuration (s)	Consistency value	Coverage value
MOTIVATION	1.00	1.00
NOAVERSION	1.00	1.00

As the table illustrates, high motivation and lack of aversion are full subsets of the outcome and such a set relation is very significant. This means that whenever a case appears with presence of these two conditions, especially when all remainders show up in reality, screening for bowel cancer follows. High motivation and lack of aversion are therefore simultaneously

both necessary and sufficient conditions for emergence of the outcome (screening) among people of high SES in Hull.

6-1-6 Intermediate solution for the outcome

Bringing directional expectations, mentioned above for the outcome when both SES groups were considered, into the minimization process leads to the intermediate solution as follows (table 36):

MOTIVATION*NOAVERSION*ATTITUDE*LOGISTIC +

MOTIVATION*NOAVERSION*NOFEAR*AWARENESS*LOGISTIC <=> **OUTCOME**

Table 36. Intermediate solution for the outcome among people of high SES in Hull

Configuration (s)	Consistency value	Raw coverage	Unique coverage
MOTIVAVATION*NOAVERSION*ATTITUDE*LOGISTIC	1.000	0.909	0.636
MOTIVATION*NOAVERSION*NOFEAR*AWARENESS*LOGISTIC	1.000	0.364	0.091
Intermediate solution	1.00	1.00	1.00

As the table shows, there are two configurations leading to the outcome, screening, among the rich participants in Hull. However, only the first configuration is a full subset of the outcome (fully sufficient and significantly important) evidentially.

6-2 Analysis for negation of the outcome

The following section covers the qualitative comparative analysis for negation of the outcome among high SES people (participants) in Hull.

6-2-1 Necessity analysis for outcome negation

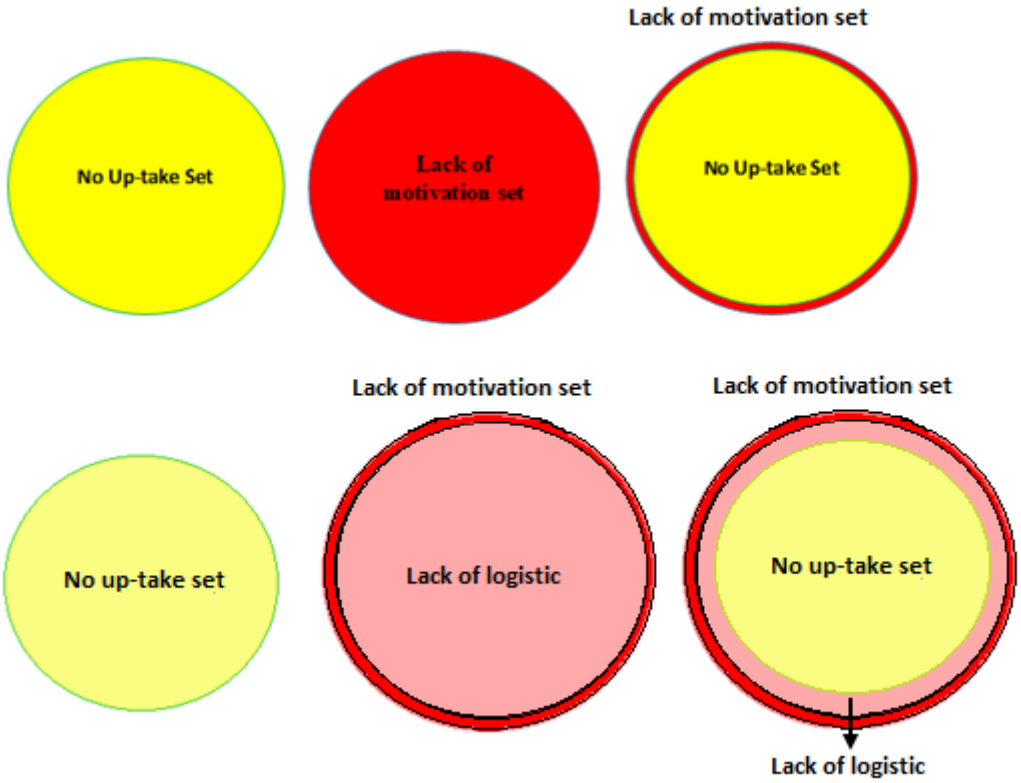
The following table shows the result of necessity analysis for the negation of outcome (not screening for colorectal cancer) among rich participants in Hull.

Table 37. Necessity analysis for outcome negation among people of high SES in Hull

Configuration (s)	Consistency value	Coverage value
Motivation	1.000	1.000
motivation*logistic	1.000	1.000
motivation*noaversion	1.000	1.000
motivation*nofear	1.000	1.000
noaversion*nofear	1.000	1.000
motivation*noaversion*nofear	1.000	1.000

As the table shows, 6 configurations are necessary for emergence of outcome negation among people of higher SES in Hull. Furthermore, as the coverage value shows, they are very relevant and significant as necessary conditions (figure 22). As figure 22 shows, for example, the intersection of lack of motivation and logistic facilities sets fully covers the lack of screening set, indicating that these two conditions are significantly important for lack of screening. Such an argument applies to other configurations in table 37 as well.

Figure 22. Schematic illustration of superset relation of lack of motivation and logistic facilities with lack of screening among people of high SES in Hull



6-2-2 Truth table for outcome negation

The following table shows the truth table for negation of the outcome among people of high SES in Hull. As the table shows, there are 9 rows (out of 64 possible rows, 55 logical remainders) that accommodate some cases.

Table 38. Truth table for the outcome negation among people of high SES in Hull

Configuration (s)	Motivation	Lack of aversion	Lack of fear	Awareness	Attitude	Logistic	Outcome	No	Consistency Value	Case
1	0	0	0	0	0	0	1	1	1.00	7
2	0	0	0	1	1	1	1	1	1.00	12
3	0	0	0	1	0	1	1	1	1.00	13
4	0	0	0	0	1	1	1	1	1.00	2

5	1	1	0	1	1	1	0	3	0.00	8,9,11
6	1	1	1	0	1	1	0	3	0.00	3,5,10
7	1	1	1	1	1	1	0	3	0.00	1,4,15
8	1	1	0	0	1	1	0	1	0.00	6
9	1	1	1	1	0	1	0	1	0.00	14

A minimization process was used to summarize the information in this truth table. The results of the minimization process are reported below.

6-2-3 Complex solution for outcome negation

The complex solution only includes rows with high consistency value (i.e. remainders are excluded). The following complex solution (table 39) was produced from the above truth table.

motivation*noaversion*nofear*ATTITUDE*LOGISTIC +

motivation*noaversion*nofear*AWARENESS*LOGISTIC +

motivation*noaversion*nofear*awareness*attitude*logistic <=> **outcome**

Table 39. Complex solution for outcome negation among people of high SES in Hull

Configuration(s)	Consistency value	Raw coverage	Unique coverage	Cases
motivation*noaversion*nofear*ATTITUDE*LOGISTIC	1.000	0.500	0.250	2,12
motivation*noaversion*nofear*AWARENESS*LOGISTIC	1.000	0.500	0.250	13,12
motivation*noaversion*nofear*awareness*attitude*logistic	1.000	0.250	0.250	7
Complex solution	1.00	1.00	-	-

As the table shows, there are three configurations that can lead to the emergence of negation of the outcome among people of higher SES in Hull. However, considering the coverage values, only the first two configurations are significantly sufficient for the negation of outcome.

6-2-4 Parsimonious solution for negation of outcome

Bringing all the logical remainders (55) into the minimization process leads to the most parsimonious solution for outcome negation among people of high SES in Hull (table 40):

motivation <=> **outcome**

noaversion <=> **outcome**

Table 40. Parsimonious solution for outcome negation among people of high SES in Hull

Configuration (s)	Consistency value	Coverage value
Motivation	1.00	1.00
noaversion	1.00	1.00

As the table shows, lack of motivation and presence of aversion are fully sufficient and significant conditions for lack of screening among people of high socioeconomic status in Hull, if all logical remainders can show up in reality.

6-2-5 Intermediate solution for outcome negation

Using directional expectations, the following intermediate solution was produced for negation of the outcome among participants with high socioeconomic status in Hull (table 41).

motivation + noaversion <=> **outcome**

Table 41. Intermediate solution for outcome negation among people of high SES in Hull

Configuration (s)	Consistency value	Raw coverage	Unique coverage
Motivation	1.00	1.00	1.00
Noaversion	1.00	1.00	1.00
Intermediate solution	1.00	1.00	1.00

As the table shows, just as in the parsimonious solution, there are two conditions that are full subsets of the negation of the outcome and can significantly lead to lack of screening for colorectal cancer in Hull. Interestingly, aversion and lack of motivation are both sufficient and necessary for lack of screening among people of high SES in Hull.

To wrap up the findings presented in this chapter, one can say only a small number of conditions, namely the motivation, was both sufficient and necessary for the desired outcome and its negation. Moreover, the number of necessary conditions and combinations for emergence of the outcome among the rich was much higher than the number for the poor. More importantly, most of the configurations revealed to be sufficient for emergence of the outcome and its negation had a low coverage score, i.e. their relationships with the outcome (or its negation) were significant, but not strong. However, this lack of strength does not undermine their significance. In the next chapter, these configurations which were sufficient for the outcome and its negation will be explored in detail.

Discussion
&
Conclusion

1- Recap of the findings

Using a complexity-informed approach, the present study was conducted to examine the configurations (of conditions) that can lead to screening (or lack of screening) for bowel cancer in Hull. In addition, having screening inequalities in mind, it aimed to discover whether the configurations differed between people of lower and higher socioeconomic status in Hull.

According to the findings, there were some necessary and sufficient conditions for emergence of the outcome (screening for colorectal cancer) and its negation among a group of people in Hull (both SES groups considered). The necessary conditions for the outcome were as follows: high motivation, positive attitude, availability of logistic facilities, "high motivation*positive attitude", "high motivation*availability of logistics", "high motivation*lack of aversion", and "lack of aversion*lack of fear of cancer". However, only high motivation was fully and significantly necessary for the outcome while the other configurations were partly necessary. As for outcome negation, the necessary conditions for lack of screening were as follows: lack of motivation, presence of aversion, "lack of motivation*presence of aversion" and "lack of motivation*fear of cancer". However, only lack of motivation was fully necessary for the outcome negation and other configurations were only partly necessary. In set theory terms, a necessary condition means that the condition is a superset to the outcome set and whenever the outcome shows up, the condition will undoubtedly be present.

In terms of sufficient conditions, there were 5 different configurations (complex solution) that were somehow sufficient to produce the outcome and that accommodate some cases in reality. However, none of the configurations were fully sufficient for the screening. However, when all counterfactuals (logical remainders) were taken into account (parsimonious solution), high motivation was a significantly sufficient condition for the outcome among the people of Hull. As for negation of the outcome, there were 6 different configurations that could lead to lack of

screening, though none of them were significantly sufficient for lack of screening. However, when all counterfactual configurations were taken into account (parsimonious solution), lack of motivation was shown to be significantly sufficient for lack of screening. In set theory terms, a sufficient condition means that the condition is a subset of the outcome set and whenever the condition shows up, the outcome will certainly be present as well.

Comparing low and high socioeconomic groups with each other, high motivation and positive attitude and their intersection were necessary conditions for screening in both groups. However, there were more contributing necessary conditions for the outcome among rich people than among the poor. For example, lack of aversion towards the test and presence of logistic facilities for the test were among the important necessary conditions for emergence of the outcome among the rich (Table 32 in chapter 4). In terms of negation of the outcome, lack of motivation was a significant necessary condition for not doing the screening in both groups. However, there were some differences between the two groups and different intersections of some conditions (e.g. fear of cancer, lack of logistic facilities) were also necessary conditions, although not as significant as lack of motivation.

In terms of sufficient conditions, a high level of motivation was significantly sufficient for the emergence of outcome in both groups. However, lack of aversion was also significantly sufficient for the outcome among higher SES people. As for negation of outcome, lack of motivation was significantly sufficient for lack of screening in both groups. However, presence of aversion towards the test among people of lower SES was significantly sufficient for lack of screening as well.

2- Explanation of the findings

Here I will explain the findings according to their importance. Because of the detailed information that complex solutions provide, my explanation of conditions and configurations

that led to the outcome or its negation in our study will be based on complex solutions. However, parsimonious and intermediate solutions will be retrieved for comparison between groups as well, as in the previous section.

2-1 Presence of the outcome

The complex solution for presence of outcome (screening) among the participants, when two SES groups are considered, was as follows.

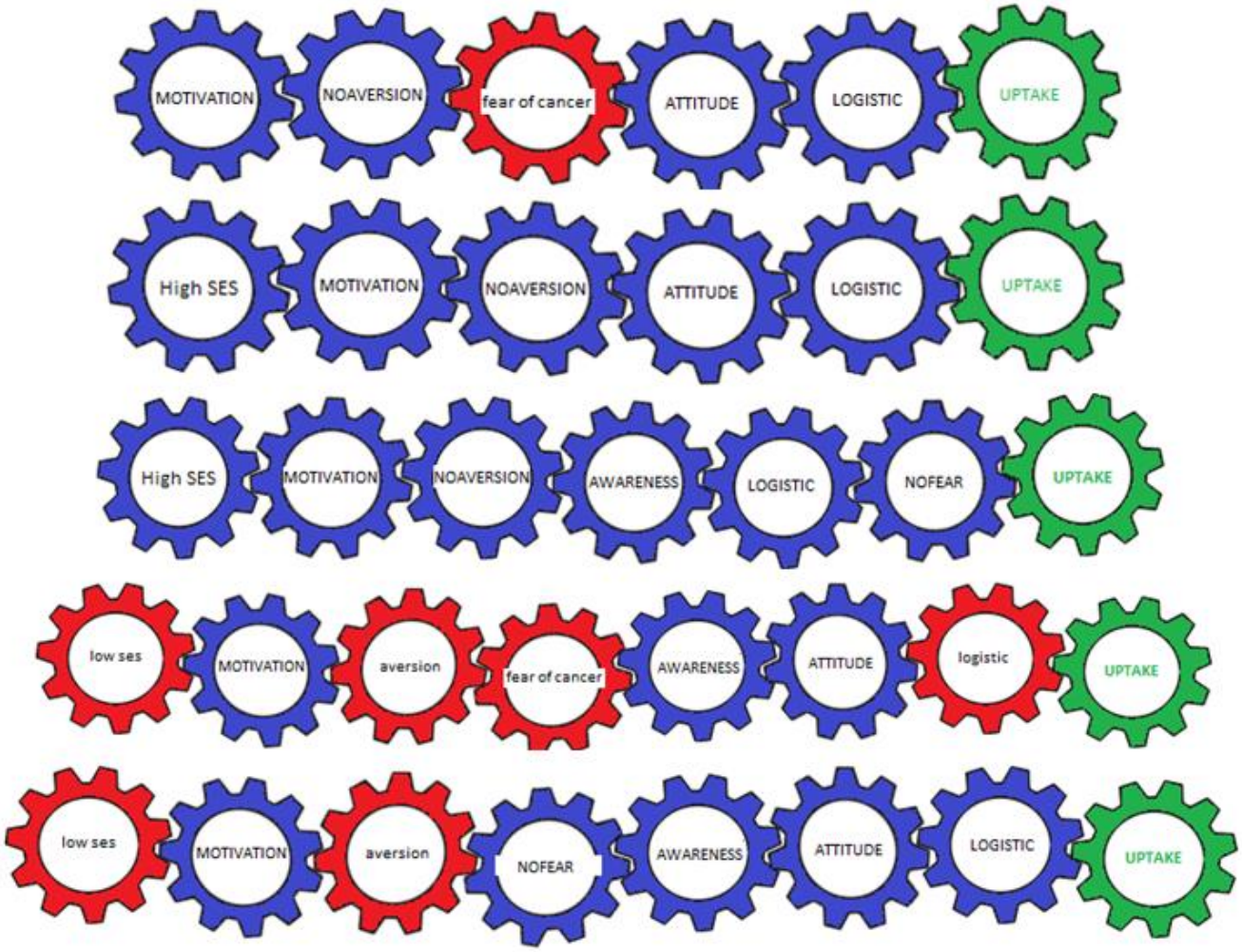


Figure 23. A schematic illustration of complex solution for outcome in Hull

As can be seen, there are five ways to look at screening uptake among the participants. The second configuration (from the top) included 10 of the participants (Table 12 in chapter 4). As this configuration shows, when these conditions (belonging to higher socioeconomic status,

high motivation, lack of aversion to the test, positive attitude, and having logistic facilities) come together, then screening uptake is observed among the cases. Although other studies have not studied these conditions as configurations, there have been quite a lot of studies supporting the effects of these conditions on screening (Palmer et al., 2008, Beeker et al., 2000, Palmer et al., 2014, Honein-AbouHaidar et al., 2016).

Socioeconomic status can be considered as the context in the present study. It is the context within which all other conditions interact with each other and with the context, and then the mechanisms (configurations) that produce the outcome find ways to appear in reality. An association between socioeconomic status and screening for colorectal cancer has been reported by other studies as well. For example, just as in the present study, in which neighbourhood-level socioeconomic status was considered as the proxy for participants' socioeconomic status, some studies have reported that higher socioeconomic status leads to a higher chance of screening (Fukuda et al., 2005, Thorpe et al., 2005, Schootman et al., 2006). In a review study, Javanparast et al. reported higher socioeconomic status as a predictor of bowel cancer screening. They also reported that barriers to screening (lack of knowledge, fear of cancer, embarrassment, lack of self-efficacy, and the inconvenience of FOBT) occur more among people of lower socioeconomic status. In our study, similarly, higher socioeconomic status was the context in which most of the positive predictors of screening configured. However, interestingly, the last two configurations in figure 23 illustrate that even when the context (low socioeconomic status) was not favourable for screening, interactions between the context and the conditions led to screening. This finding is of especial importance as such findings are reported in the literature, and it also highlights the complexity of screening determinants (complex causality) and the importance of detailed investigation of these configurations and the cases within them. Taking a close look at these two configurations shows that aversion, fear of cancer, and lack of logistic facilities are present in them, namely

in the first one. This configuration is really interesting as the cases within it fear the cancer diagnosis, are aversive towards the test, and lack facilities, yet still take up the test. Upon close examination, one of the cases is revealed to be a retired man (formerly a shopkeeper) who lives with his wife, had experienced the loss of his brother because of stomach cancer, and reported spousal and family pressure to take up the test. To be precise, he is highly motivated (external motivation) to take up the screening test. In the following, some of his thoughts are provided:

"*My brother, older one, died of bowel issues, cancer I mean. That period of life was tough as he was going through something, pain and indigestion, unthinkable. So, I am afraid that might be in genes, a problem in family*"

"*My wife and children are watching me in a sense, I mean they just shovel me to take the tests, this bowel one included. My wife starts nagging if I throw the test away*"

High motivation, in fact, was among the main conditions that took part in all the configurations that led to uptake of screening in figure 23. Indeed, motivation was a highly necessary condition for the outcome and all the cases with uptake were subset of the motivation set. Talking in complexity theory terms, motivation proves to be a "first-order control parameter" in the complex cases examined in the present study. Control parameters are the elements in a complex system which, if they change, produce a qualitative change in the nature of the system so that the system will move towards a new attractor (e.g. screening) in the state-space. In line with this finding, motivation has been reported as one of the facilitators of screening in other studies as well. For example, Fyffe and colleagues reported that motivation was among the main determinants of screening among black men in the USA (Fyffe et al., 2008). In a very comprehensive systematic review, Honein et al also reported that (high) motivation is among the main facilitators of and contributors to screening for bowel cancer (Honein-AbouHaidar et al., 2016).

Aversion towards the test was also among the main conditions in the configurations that led to uptake of screening in figure 23. Against this finding, studies from the UK (Chapple et al., 2008, Palmer et al., 2014), Singapore (Foo et al., 2011), Spain (Molina-Barcelo et al., 2011), and Australia (Javanparast et al., 2012) have shown that aversion towards the test (FOBT) is one of the main barriers to screening (although they studied it as an independent variable and not in a configuration). In fact, our study showed that although aversion towards the test can be present in some cases, it is the configuration of conditions that can lead to screening, something that is quite against common sense and what other studies have reported so far (Aubin-Auger et al., 2011). This fact lends further support to the importance of configurational thinking (causal complexity) for screening over the independent net effect approach (Byrne and Ragin, 2009).

Lack of fear of cancer diagnosis was also among conditions within the configurations that, as might be expected, could lead to uptake of screening in figure 23. Fear of cancer (and its lack) has been cited as one of the main barriers (and sometimes facilitators) to screening in the literature (Palmer et al., 2008, Holmes-Rovner et al., 2002, O'Sullivan and Orbell, 2004, Brouse et al., 2003, Greiner et al., 2005, Chapple et al., 2008, Feeley et al., 2009, Good et al., 2010, Foo et al., 2011, Garcia-Dominic et al., 2012, Jilcott Pitts et al., 2013, Ekberg et al., 2014, Clarke et al., 2016). Our study finding is therefore, in a sense, in line with most other studies about the role of fear of cancer in screening. However, against the current evidence and consensus, we have also shown that, like test aversion, presence of fear within a configuration may also lead to screening, namely in the first and penultimate configurations in figure 23. This finding could be due to the configurational approach that we have taken and to the fact that it views the conditions in configurations and not on their own. There is a call in the literature to do more research on the effects of fear on screening, especially in terms of understanding its, seemingly contradictory, deterring and facilitating effects on screening (Cossu et al., 2018).

Our study findings may be a contribution to such understanding as we show that depending on what configuration the fear of cancer sits in, the effect of the fear may differ.

Awareness or knowledge of bowel cancer (symptoms) and screening (its purpose) is among the (necessary) conditions within the configurations that lead to screening for bowel cancer. Interestingly, and in contrast to some studies (Weitzman et al., 2001, Coronado et al., 2006, Holt et al., 2009, Winterich et al., 2011, Javanparast et al., 2012), the level of knowledge about colorectal cancer and its screening was satisfactorily good in Hull. A good level of awareness (not its lack) has been on the list of contributors or predisposing factors for screening for bowel cancer in many studies (Beeker et al., 2000, Weitzman et al., 2001, Brouse et al., 2003, Brouse et al., 2004, Greiner et al., 2005, Coronado et al., 2006, Fernandez et al., 2008, Goldman et al., 2009, Javanparast et al., 2010, Aubin-Auger et al., 2011, Garcia-Dominic et al., 2012, Dharni et al., 2016). For example, in a very comprehensive review, Honein and et al. showed that awareness is at the centre of a model of screening determinants. (Honein-AbouHaidar et al., 2016). In a recent study in the UK, Dharni and colleagues showed that lack of awareness was a barrier for all the participants, regardless of their SES and ethnicity (Dharni et al., 2017). However, as our study shows (the first and second configurations in figure 23), it is possible to see cases, as indeed with most of the cases in our study, for whom awareness is not important and awareness-free configurations of conditions can successfully lead to screening. This finding conflicts with many studies and policies/interventions that see awareness as a very important contributor to screening, and this is one of the main contributions of the present study, with various implications for future interventions (to be discussed in the following sections). Moreover, it is worth adding that since neighborhood socioeconomic status (context) was chosen as the proxy for the socioeconomic status of participants, for ease of casing (sampling), the relationship between the education level of participants and their awareness about screening was not a matter of importance. In fact, considering the relatively high

knowledge of screening among participants in both socioeconomic groups, it is highly plausible that there was no significant relationship between screening awareness and education level. However, this kind of justification does not negate the importance of education level for other conditions (e.g. attitude or motivation) or the emergence of specific configurations in Hull. This issue needs more exploration in future studies of the reasons behind patterns of screening in Hull.

Positive attitude towards screening is also among the conditions that, like motivation, appears in almost all of the configurations that lead to screening. This finding is in line with a plethora of studies in public health about the effects of a positive attitude to the effectiveness/usefulness of screening for colorectal cancer (Goel et al., 2004, O'Malley et al., 2004, Greiner et al., 2005, Friedemann-Sánchez et al., 2007, Feeley et al., 2009, Foo et al., 2011, Woudstra et al., 2016). However, our study also showed that there can be cases where attitude (positive or negative) (the third configuration in figure 23) is not important for screening, and both can be part of configurations that can lead to screening. This fact again shows that a single equation of behavioural prediction does not suffice to explain decision processes related to screening. It is the configuration, within which the variables sit, which determines the behaviour of cases, and not single variables.

The presence of logistic facilities was also among the conditions within the configurations that could lead to screening for colorectal cancer. Logistic amenities, their presence and absence, have been reported in a couple of studies as one of the conditions that positively determine screening outcomes for bowel cancer (Good et al., 2010, Jones et al., 2010, Honein-AbouHaidar et al., 2016). However, our study also showed that there can be combinations of conditions in which it is entirely possible not to have the required logistic facilities (a place to safely keep the FOBT test kit) as one of the conditions , but which show the screening behaviour (the fourth configuration in figure 23). Such a possibility was not reported in any

reviewed studies, to the best of the author's knowledge. However, despite such interesting findings, one can postulate that the importance of logistic factors in the present study may point to the underlying deprivation level in Hull. In fact, Hull is one of the most deprived regions in England, and such deprivation can translate into the importance of logistic factors in studies of screening for colorectal cancer.

To sum up, the findings mentioned above showed that screening for colorectal cancer is a complex issue and that no single model/theory/framework/path can sufficiently explain screening behaviour. This justifies the calls and attempts, such as the present study, to use complexity-informed approaches to study this phenomenon. However, there are few studies, to the best of the author's knowledge, which have taken such an approach. In one of those few studies, Wackerbarth and colleagues tried to model and reveal the patterns related to the decision to screen for colorectal cancer in the USA (Figure 24). Although they did not use a complex systems outlook, it was in some sense a complexity-informed approach as it employed, in a very basic manner, complex causality concepts (i.e. equifinality and complexity of the cause). In fact, in order to reveal the patterns of decision-making related to screening, the researchers used Kurt Lewin's field theory of decision-making. According to the findings, there were 6 different patterns (configurations in complexity terms) relating to the decision-making process among the participants within which one particular factor was the strongest and most influential (first order control parameter in complexity terms). The patterns were as follows: (1) "O.K. Doc", which points to a strong effect, indicating a driving force, of healthcare provider on the screening decision. (2) "I would like to be screened, but", which points to hurdles that barriers such as lack of insurance coverage create on the route to screening. (3) "I do not need screening", which refers to restraining factors, such as lack of symptoms or lack of family history, which hold people back from going for screening. (4) "Not again", which is relates to previous experiences that are strong enough to prevent screening

behaviour. (5) “But on the other hand”, which points to cases in which, despite recommendation from healthcare providers, patients had other stronger internal forces pushing them to make a trade-off and decline the screening. This path is similar to the motivational effects observed in the present study. (6) “What? No one recommended it”, which points to the assertion that no provider had told the participants that they had to have screening. Finally, (6) “I have been screened, haven’t I”? that points to patients who believed that as they had had regular check-ups or screens before, they did not need any further screening for colorectal cancer. Although useful, especially in terms of understanding screening reasons and policy implications, there were some basic drawbacks in Wackerbarth and colleagues’ study. First, they did not explicitly reveal the structure (the conditions within each path) of each path to screening. Second, they did not reveal the importance and significance of each path (coverage and consistency values in complex systems terms). And finally, they did not run the analysis for negation of the outcome to reveal the paths for that as well (Wackerbarth et al., 2008).

2-2 Negation of the outcome

The analysis for negation of the outcome (not doing the screening) when both SES groups were considered showed that there were 6 configurations of conditions that could prevent cases from going for screening (figure 25). Necessity analysis also showed that lack of motivation to do the test can significantly prevent screening (Table 15 in Chapter 4). To put it another way, lack of motivation was a superset of the outcome negation set (set of all cases who did not take up the test) and the set relation was full and complete.

As figure 25 shows, the first configuration is made up of all the factors that can logically (evidentially) act as barriers to screening. There has been a huge number of studies pointing to these factors in the literature. For example, in a study by Dharni et al. in the UK, almost all of the factors in this configuration were found to be acting against participation in screening for

bowel cancer (Dharni et al., 2017). In another study, Palmer and colleagues investigated the reasons for non-uptake of bowel cancer screening in the NHS. They also reported similar factors acting as screening barriers (Palmer et al., 2014). However, other configurations in figure 25 had conditions within them that conflict with current knowledge, i.e. they do not in themselves prevent screening, but within the configuration as a whole, they acted against going for screening. These conditions are high awareness and good logistic facilities in configuration 2; higher SES, positive attitude, and good logistic facilities in configuration 3; high awareness and positive attitude in configuration 4; high awareness and lack of fear of cancer in configuration 5; and lack of aversion and good logistic facilities in configuration 6.

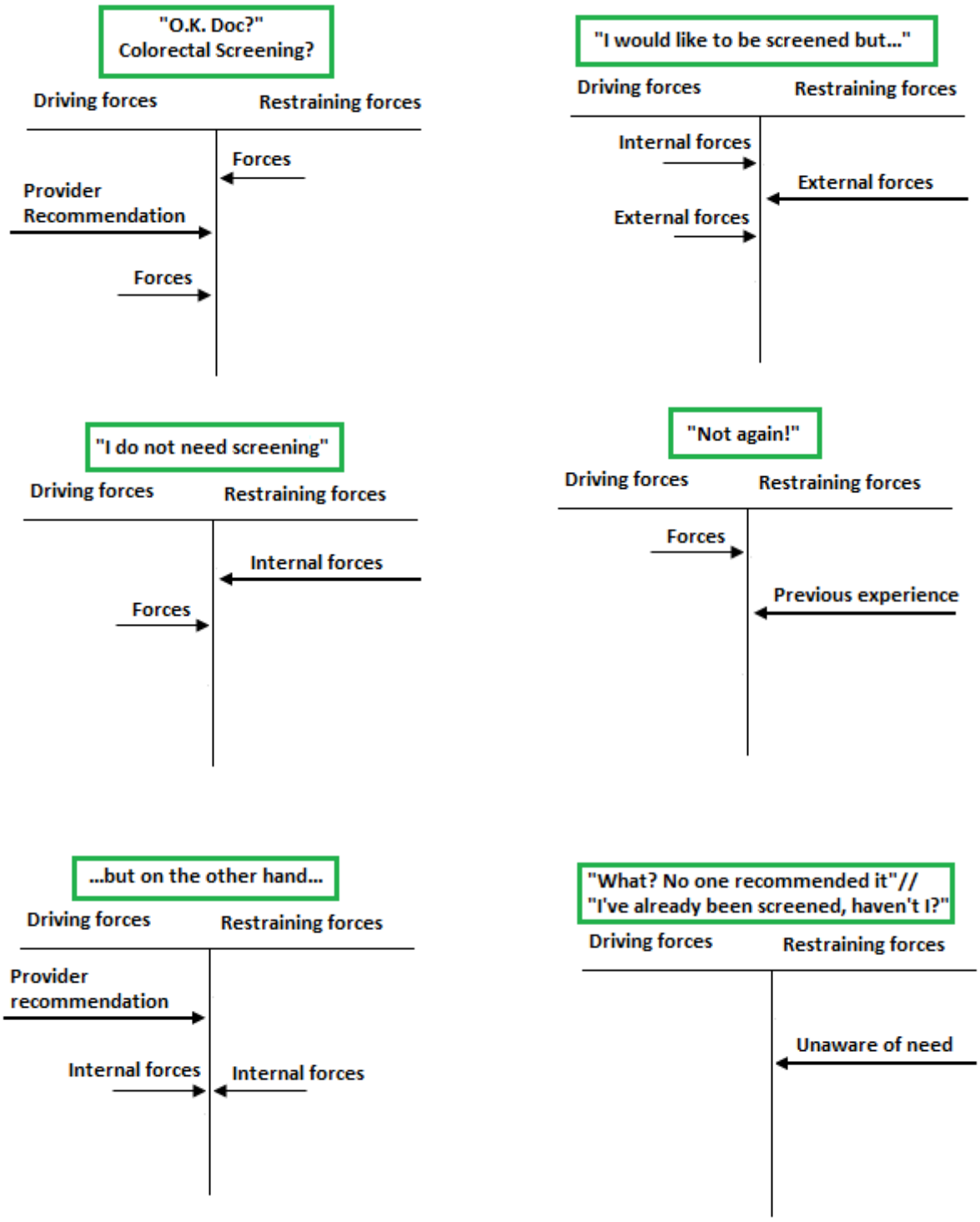


Figure 24. Six paths of screening according to Wackerbarth and colleagues

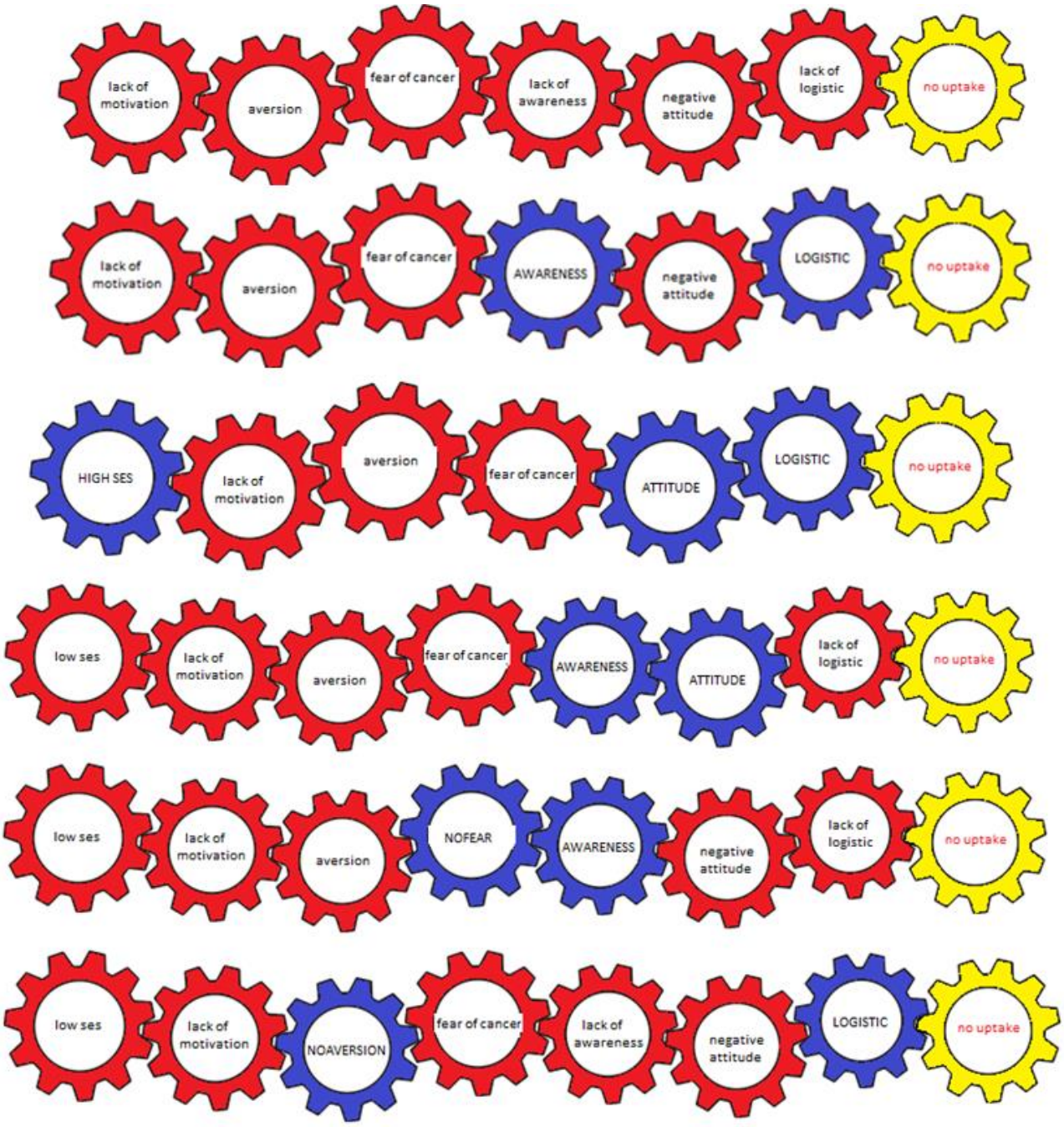


Figure 25. A schematic illustration of complex solution for outcome negation when both SES groups are considered

Interestingly, high awareness was present in almost all of the configurations that acted against screening. This ostensibly challenges what Honein et al. reported in their meta-theory of screening, as awareness was seated in the centre of their model, affecting almost all the determinants of screening (Honein-AbouHaidar et al., 2016). However, in our study we can

see that some configurations overcame the awareness condition. Awareness failed to push the configuration towards screening, as other conditions 'fought back' and pushed the cases (systems) away from the screening (the attractor). This is a very interesting finding with far-reaching implications for future policy-making and research, which will be discussed in the following sections.

In terms of the effects of socioeconomic status on screening (screening inequality), almost all of the cases (configurations/systems) who did not take up the screening belonged to the lower part of the social ladder, i.e. disadvantaged people in Hull. However, there was also one configuration (3rd configuration in figure 25) relating to people of higher socioeconomic status, containing three cases. This configuration shows that it is possible to have a situation in which interactions and mechanisms between the context of high socioeconomic status and other conditions can lead to non-uptake of screening. However, such inequality, which disfavours the poor, was not evident when analysis was done for the outcome (screening). As shown in figure 23, most of the configurations in that figure sat in the context of higher SES, showing that screening favoured the advantaged. However, again there were configurations in figure 23 in which a context of lower socioeconomic status can configure with some other conditions and lead to screening. These findings all show that, although we can see inequality in screening, there are various paths leading to screening or not-screening, and treating them all as one path, as is done in non-systemic science, can be misleading. This issue will be further examined in the next section.

3- Socioeconomic status (SES) and inequalities

The analysis for the outcome and its negation showed some differences between people of low and high socioeconomic status in terms of the configurations as follows. As figure 26 shows, the configurations that led to uptake of screening were different for people of low and high

socioeconomic status. There were two configurations that could lead to uptake of screening among the rich; these two configurations are comprised of all the conditions that are positively, theoretically and evidentially (Severino et al., 2009, Manne et al., 2012, Aubin-Auger et al., 2011), related to uptake. Moreover, almost all of these conditions were completely necessary for uptake (Table 32 in chapter 4). Therefore, all the conditions, and their combinations, which were necessary and relatively sufficient for the outcome went hand in hand to produce the behaviour among people of higher socioeconomic status. In contrast, the configurations that produced the outcome (screening) among people of lower socioeconomic status included some conditions (fear of cancer, aversion towards test, and logistic problems) that according to the literature should prevent screening (Hoffman-Goetz et al., 2008, Ritvo et al., 2013). This is very interesting as it shows that these negative conditions are more concentrated among the poor, but the interactions between the conditions and the context may produce unexpected outcomes. Interestingly, high motivation and positive attitude were consistently present across all the configurations in both socioeconomic contexts.

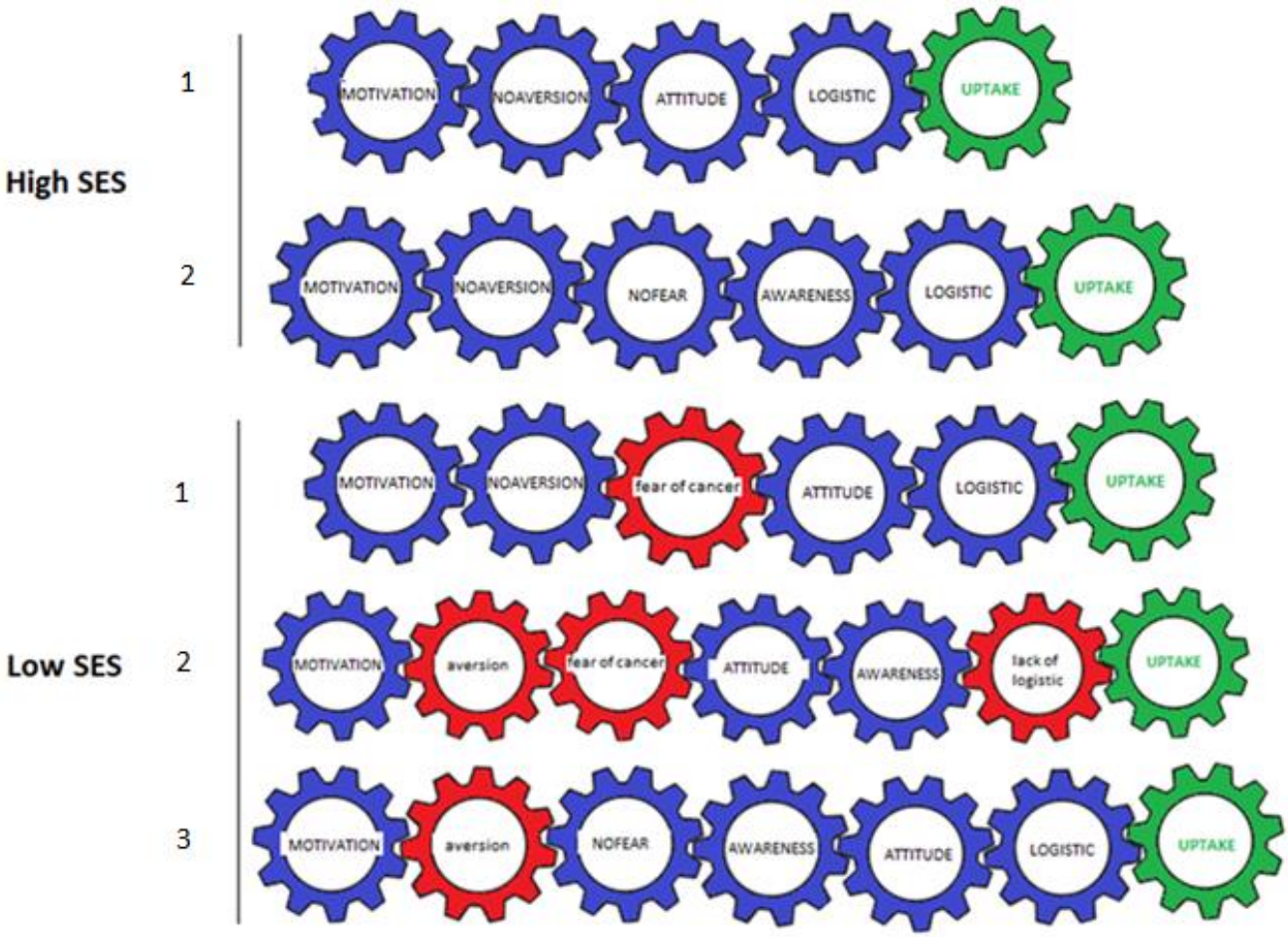


Figure 26. A schematic illustration of complex solution for the outcome when SES groups are considered separately

Figure 27 illustrates the analysis for negation of the outcome (lack of screening) in the two socioeconomic groups. As the figure shows, not only are the configurations different between the two groups, there are more configurations among the poor that can lead to lack of screening. Interestingly, there is only one configuration (the first one) among the poor that is comprised of all the negative conditions that could be expected to prevent screening. All the other configurations in both socioeconomic groups are a combination of negative and positive conditions; negative conditions have the upper hand and finally lead to lack of screening. More importantly, lack of motivation was consistently present across all configurations in both socioeconomic groups.

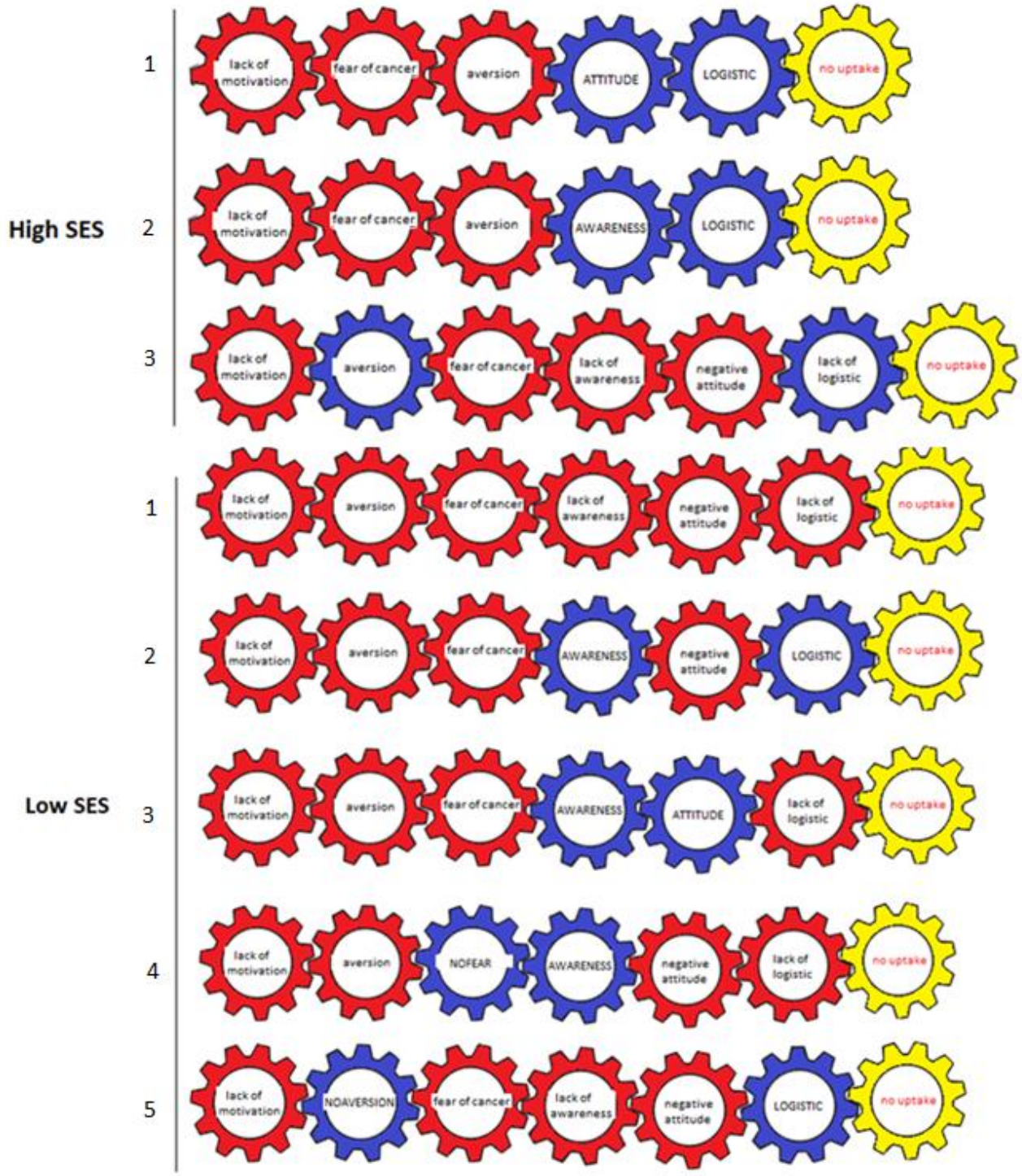


Figure 27. A schematic illustration of complex solutions for outcome negation when SES groups are considered separately

There has been a plethora of studies reporting unequal uptake of colorectal cancer screening across the world (and in the UK) (Lo et al., 2015a, von Wagner et al., 2011a, von Wagner et al., 2009, Solmi et al., 2015). For example, in a recent national study in the UK it was shown that CRC screening is unequally distributed across the country and that economic status (wealth) accounts for 40% of the inequality observed (Raine et al., 2016a). However, few studies so far have attempted to investigate the mechanisms that link socioeconomic status to the social cognitive factors that are more proximate, at least theoretically, to screening behaviour. In one of the most comprehensive studies, von Wagner and colleagues investigated the psychosocial determinants of socioeconomic inequalities in screening behaviour for (all) cancer (s) (von Wagner et al., 2011b). Their study suggested a conceptual framework in which attitudinal mediators, namely the perceived threat of cancer diagnosis (fatalism), self-efficacy, and response-efficacy linked the socioeconomic status/context to the behaviour. Although the framework was interesting and evidence-driven, it called for future studies to empirically examine the pathways that the model suggested. Our findings, however, are not in line with that framework; that is, different mechanisms and factors, and not fatalism, self-efficacy, and response-efficacy, link the socioeconomic factors to the behaviour. One reason for this may be the catch-all nature of von Wagner and colleagues' study, as it included all cancers (with various screening modalities), while the present study only focused on colorectal cancer.

There have been some other studies that have reported findings that are in line with the present study. For example, Lo and colleagues investigated the socio-cognitive mechanism underlying inequalities in colorectal cancer screening in UK (Lo et al., 2015b). According to their findings, socioeconomic disparities in uptake were mediated by three socio-cognitive factors: screening knowledge, social norms, and perceived barriers. By social norms, the study referred to the impact of other important people's ideas and screening behaviour on participants' screening behaviour; by perceived barriers the study referred to the impacts of embarrassment, disgust

(aversion), and practical barriers on the screening behaviour of participants. The authors used the Structural Equation Modelling (SEM) approach to reveal the pathways through which socio-economic-cognitive factors lead to screening uptake (inequalities). The study showed that the pathways are multidimensional, and single-factor interventions are not the answer. Figure 28 illustrates the pathways that linked socioeconomic status to screening, mediated by cognitive factors.

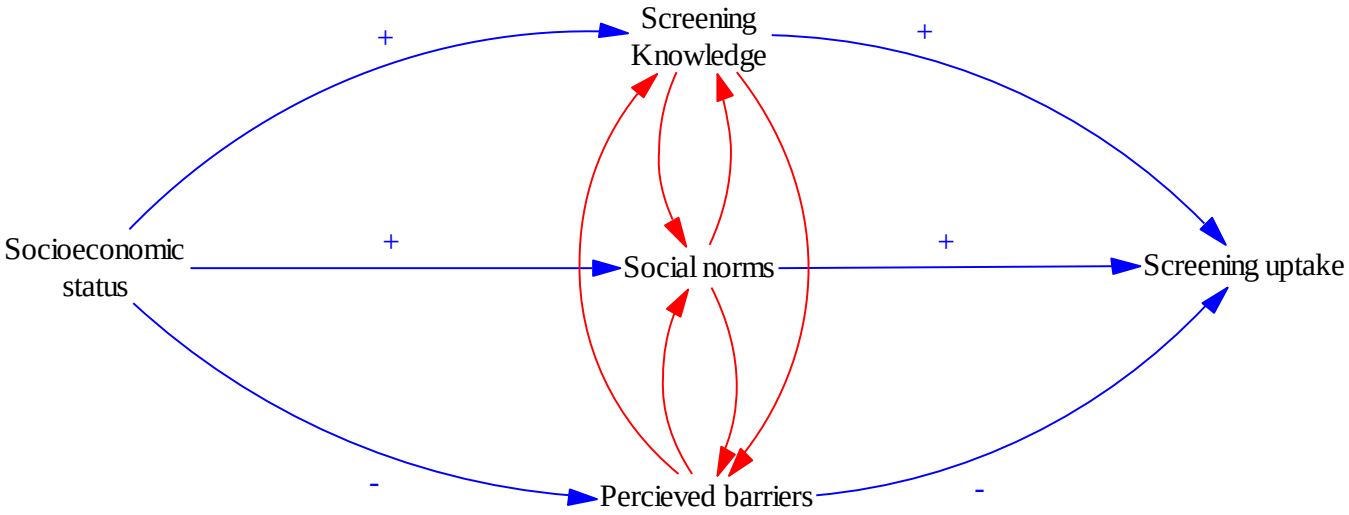


Figure 28. Pathways from socioeconomic status to screening behaviour

As the figure shows, there are three simple pathways from socioeconomic status to screening (blue arrows). Positive and negative signs show the direction of the relationship/correlation between the variables (direct or reverse, respectively). As the study reported, the three cognitive factors were also correlated with each other (red pathways), but the study fails to account for this in the pathways, thus ignoring the complexity of pathways from socioeconomic status to screening. Moreover, it was not reported which pathway was more important. More importantly, as in other non-configurational studies, negation of the outcome is taken as equivalent to the outcome and the pathways that can lead to outcome negation are ignored. In addition, the developed model does not illustrate which configurations of conditions can lead

to screening behaviour in rich as opposed to poor people, and only the overall correlations and pathways are reported. In spite of such limitations, however, the study has some similarities with the current study: social norms can be considered as an external motivation, and this is in line with the importance of motivation in our study. In addition, knowledge and perceived barriers (i.e. aversion and practical barriers) are also significant factors influencing screening in our study. Above all, Lo and colleagues' study is one of the few studies to refer to practical barriers (called logistic factors in our study) as determinants of screening. In conclusion, one can say that Lo and colleagues' study is a simpler version of pathway (configurational) thinking about colorectal cancer screening and inequalities.

In another study by Jane Wardle and colleagues, using data from randomised controlled trials in the UK, psychosocial and cognitive models that explain the inequalities in participation in colorectal cancer screening were compared (Wardle et al., 2004). According to the psychosocial model, high stress and low social support (which may be predominant in deprived environments) are the reasons behind lower rates of screening for colorectal cancer. According to the cognitive model, differential beliefs and expectations about cancer and screening (e.g. perceived risk of cancer, worry about bowel cancer, perceived benefits of screening, perceived barriers to screening, fear of screening, and fatalism) across socioeconomic classes are more important in explaining the differential screening behaviour. Using a series of regression analyses, Wardle and colleagues' study showed that only cognitive factors are able to mediate the relationship between socioeconomic status and screening behaviour. Interestingly, knowledge of cancer and screening (perceived risk of cancer, perceived benefits of screening, perceived barriers to screening) was low among people of lower socioeconomic status, but worry, fear, and fatalism were high among them. Wardle and colleagues postulated that such a concentration of cognitive factors among the deprived is the reason for inequalities. Some of their findings are in line with the present study; our study also showed that lack of knowledge

and fear of cancer were more prevalent among people in deprived neighbourhoods. However, for Wardle and colleagues, motivation was not a sufficiently significant as a factor to be included in their analysis. More importantly, a configurational and multi-pathway approach to screening (inequalities) was missing from their study and it thus failed to show how (in what ways) these factors sit together among people of low and high socioeconomic status to produce their screening behaviour.

In another recent study in the UK, Smith and colleagues investigated the psychological constructs that contribute to educational (socioeconomic status defined by education level) differences in the intention to screen for colorectal cancer (Smith et al., 2016). The educational level ranged from "no formal education" to "high school level education", to "university level education". The psychological constructs were as follows: perceived emotional barriers (i.e. aversion, embarrassment, cancer worry, and fear of cancer diagnosis), perceived practical barriers (logistic facilities), and perceived benefits of screening. Multivariate regression analysis showed that there was a significant educational gradient in distribution of perceived emotional and practical barriers in the UK, i.e. people with lower levels of education experienced higher levels of these barriers. These barriers had a significant negative association with screening intention. Moreover, people with lower levels of education reported lower levels of perceived benefits of screening. As a result, the investigators postulated that the high concentration of perceived emotional and practical barriers and the low concentration of perceived benefits among people of lower educational level (and vice versa), and their relationship with screening intention, lead to a disparity in screening in the UK, disfavouring these people. Although this study lacked a complexity-informed configurational approach to screening behaviour, these findings are in line with some of the present study´s findings. Namely, we also showed that fear, aversion, and lack of logistical facilities are more

concentrated among people of lower socioeconomic status and are among significant conditions that shape screening behaviour (as elements of some configurations).

There have been other studies attempting to discover how socioeconomic status produces differential colorectal cancer screening behaviour that are not in line with the findings of the present study. For example, Miles and colleagues used a path analysis approach to understand the psychological mediators of the relationship between colorectal cancer screening and socioeconomic status (Miles et al., 2011). Their study showed that there were 3 pathways linking socioeconomic status to screening (Figure 29).

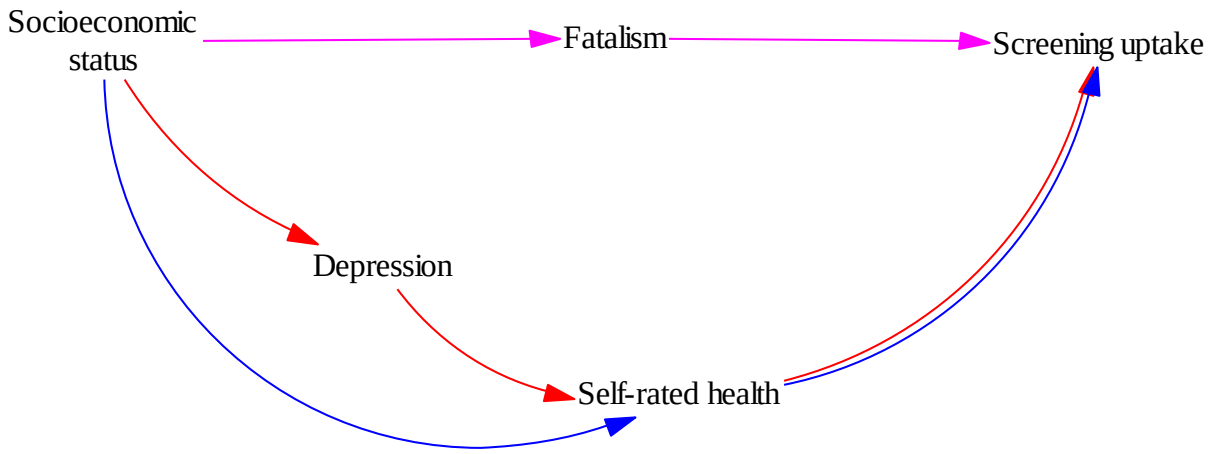


Figure 29. Pathways from socioeconomic status to screening

According to the first pathway, higher socioeconomic status leads to low cancer fatalism which then leads to screening. In the second pathway, higher socioeconomic status leads to lower levels of depression which are associated with higher levels of self-rated health. Better levels of self-rated health then lead to uptake of screening. Finally, in the last pathway, higher socioeconomic status creates higher levels of self-rated health which are associated with screening for colorectal cancer. Such pathway reasoning can be applied to lower socioeconomic status as well. This study, while using different variables, is close to our study

methodologically. However, it lacks the richness of the present study, in terms of both the number of included variables and the revealed pathways.

Now, after exploring the configurations of conditions leading to screening or its negation among people of high and low socioeconomic status in Hull and comparing these findings with the existing literature, the time has come to investigate the importance of motivational factors in our study and compare it with the international literature.

4- Motivation

Motivation for screening (or its lack) was one of the main conditions across all the configurations that consistently led (or did not lead) to screening. In fact, motivation and its lack were fully necessary for uptake and lack of uptake of screening, respectively. Interestingly, Honein et al.'s meta-analysis suggested that it is awareness that helps people to challenge and overcome structural and motivational barriers for screening (Honein-AbouHaidar et al., 2016), but our study suggested that, on the contrary, it is motivation that can help people to overcome structural and informational barriers.

Following the reviewed literature, motivation could mean one of the following factors in our study: (1) being conscious and pro-active about health and taking up screening to have peace of mind (Severino et al., 2009, Bass et al., 2011, Palmer et al., 2008, Oscar, 2009, Jilcott Pitts et al., 2013, Clavarino et al., 2004, Weitzman et al., 2001); (2) having a close friend affected by CRC and a feeling of vulnerability and doing the test as a result (Severino et al., 2009, Molina-Barcelo et al., 2011, Oscar, 2009, Jilcott Pitts et al., 2013, Ekberg et al., 2014, Bong and McCool, 2011, Ogedegbe et al., 2005, Feeley et al., 2009); and (3) spouse and family members as instrumental motivators (Molina-Barcelo et al., 2011, Holmes-Rovner et al., 2002, Oscar, 2009, Ekberg et al., 2014, Manne et al., 2012, Holt et al., 2009, Greiner et al., 2005). On the other hand, lack of motivation meant the following factors: (1) witnessing the death of

a family member or friend due to colorectal cancer and not taking the test as a result (Molina-Barcelo et al., 2011, Aubin-Auger et al., 2011, Palmer et al., 2008, Garcia et al., 2011, Jones et al., 2010, Jilcott Pitts et al., 2013); and (2) presence of competing health or social concerns (Molina-Barcelo et al., 2011, Aubin-Auger et al., 2011, Palmer et al., 2008, Garcia et al., 2011, Weitzman et al., 2001, Foo et al., 2011). As shown, many studies, in line with our study, have reported that motivational factors can play a role in screening behaviour. However, the reason why motivational factors are so important for screening in Hull should be pondered deeply. Interestingly, peace of mind was the most referred-to factor as the motivation for doing the screening in the present study. For example, one participant put it this way:

"My friend is 72 and no one could make her do the test, but personally I want to know the answer. I am taking the test for my peace of mind and if by doing the test it keeps me going for few more years, then yeah will do very happily." (Male, 66 years old)

Another participant put it in the following way:

"You have got to do it if it is something that is going to help you, give you peace of mind. Because it just gives you, although it is not 100%, like some say it is 90%, it gives you a secure sense, puts you in peace of mind". (Female, 66 years old)

Interestingly, only a few participants pointed to the role of their spouses or family members as instrumental motivators in our study. This, according to the interviews, might be due to the fact that family members rarely talk about colorectal cancer screening in Hull and screening is not a topic to be brought up in discussions. There was a remarkable number of quotes similar to the following in this regard:

"*No, I never told anyone because I think it is a very personal thing. You know going to the toilet, I won't discuss it. It is not something I could discuss it with someone. Not even a closest friend if I had one. And certainly, I don't say to my family members either".* (Male, 68 years old)

On the contrary, having a member in the social circle with (colorectal) cancer and not wanting to know what is happening in the body were, for most participants, the main reasons to dis-motivate them from taking up the test, especially among the poor. For example, one of the participants said the following:

"My husband died of liver cancer. From diagnosis to death took only 4 months. I think that made me more afraid of how quickly it could happen, you know what I mean. It totally disheartens me, you go this year and they say there is nothing and next year you go and they say cancer is there and you die soon, like my dad, so what is the point of screening?!". (Female, 64 years old)

Or,

"I do not want to know what is happening inside. It gives me inner peace not knowing, if I am to die, I will die. I prefer so, though it might seem odd for someone". (Male, 61 years old)

However, the reason why motivation stands at the centre of our results is not clear and could be examined more. One reason for such a finding might go back to the high level of screening awareness in Hull, as most of the participants had knowledge about colorectal cancer and screening for it (most of the information coming from mass media and the test-kit leaflet, even when they did not take up screening). Such information might have stirred some willingness within people's minds to be more conscious of their bowel health and to screen for bowel cancer to have peace of mind. However, poor people were less motivated to do the test, and this might be due to several factors. First, the poor might have less willingness or less time to follow mass media programmes about colorectal cancer. Second, cancer and its severe cases are more prevalent among the poor (normally because of late diagnosis) and they are therefore in greater contact with people with cancer, especially severe cases. This might discourage them, indicating that they have less control over the disease, and as a result they see no value in screening. This has been shown in couple of studies. In a study by Palmer and colleagues, for

example, it was shown that people who experienced affliction and death of family or friends due to CRC saw less benefit in screening; this was more obvious among the poor ((Palmer et al., 2008). In line with our study, Oster and colleagues in Adelaide, Australia, also reported that motivational factors were the main determinants of CRC screening. The reported motivational factors in their studies were as follows: 1) Wanting to know about CRC status (knowing-induced peace of mind); (2) Not wanting to know about CRC status (ignorance-induced peace of mind); (3) and screening as self-care (being health conscious and taking personal responsibility) (Oster et al., 2013). Moreover, higher levels of education, especially among people of higher socioeconomic status, can be another reason for the importance of motivation for screening in our study. In fact, it is shown in previous studies that people with higher education levels care more about their health (higher health consciousness) and seek screening to keep healthy and have peace of mind as a result (Honein-AbouHaidar et al., 2016). In our study as well, the better-off had higher levels of education and cared more about their health and body.

However, to better understand and articulate the findings associated with the prominence of motivational factors in CRC screening in Hull, the author has decided to resort to one of the main psychological theories about motivation. Self-Determination Theory (SDT) is a general theory of motivation that focuses on the degree of autonomy of behaviours; the extent to which the behaviour germinates from the self (internalized or intrinsic motivation) versus the extent to which the behaviour is controlled by interpersonal context (extrinsic motivation) (Patrick and Williams, 2012). According to SDT, motivation can be seen as the psychological energizer of behaviours; the source of energy can be either internal or external. Internalized behaviours are more likely to be sustained and continued. Based on SDT, human beings have three basic psychological needs that must be supported and met if a behaviour is to be more motivationally internalized and self-regulated. These needs are as follows: autonomy, competence, and

relatedness. Autonomy refers to the need of human beings to be choiceful and volitional in terms of their conducts. Competence (self-efficacy) refers to the need to feel capable of making outcomes happen. And finally, relatedness is about the need to be socially accepted and understood by important others. Relatedness can create a space in which one can more easily open up about one's personal concerns and challenges, without being harshly judged. Moreover, STD scientists add social context to the theory as well. In fact, the social context that surrounds human beings can be supportive or thwarting of these psychological needs. If a group of people can effectively satisfy these needs in a given context, they are more likely to be autonomously self-regulated in terms of the corresponding behaviours in that context and vice versa (figure 30).

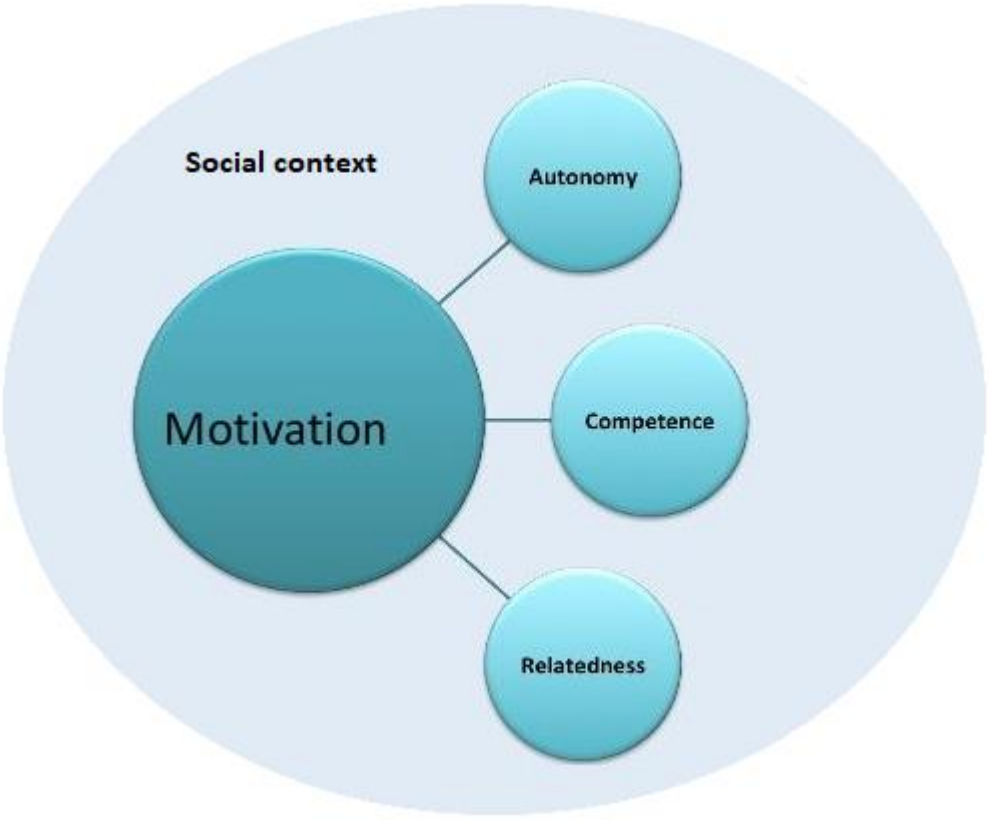


Figure 30. Schematic illustration of self-determination theory

Taking a SDT approach to CRC screening, one can say that two of the psychological needs in SDT are sufficiently met in the UK system of screening. First, take-up of the screening is volitional and left to the person to decide on. This satisfies the autonomy element of the theory. In addition, as the test (FOBT) is very user-friendly and easy to do, competence (self-efficacy) is not a big issue for the people handling it, even among the elderly. So, the second element of the theory is essentially satisfied as well. However, relatedness is where many people fail, as shown in our study and probably in the whole of the UK. In other words, the system of CRC screening in the UK is devoid of a very important aspect of healthcare use, i.e. the relationship between physicians and the people screened. The role of the healthcare system, especially the physicians' recommendation, has been reported as one of the main facilitators of CRC screening around the world (Aubin-Auger et al., 2011, Holt et al., 2009, Waller et al., 2012). In a national study in the UK, for example, Waller and et al. studied the general public's preference for an expert´s recommendation in order to make an informed decision about CRC screening, while respecting the values and preferences of the individuals. Interestingly, 84% of participants requested such a recommendation (47% strong recommendation, and 37% recommendation plus individual decision-making advice) from the health authorities (Waller et al., 2012). The researchers, then, concluded that an expert recommendation can be a salient part of autonomous decision-making in terms of health behaviour, a finding in line with our reasoning in this study. Such a relatedness could be especially helpful to people of lower socioeconomic status as they normally enjoy less instrumental help from their families/partners and, simultaneously, experience higher rates of cancer in their circle. Having such a relatedness, then, can act as a buffer and provide the motivation for these people to take up the test, despite the presence of negative dis-motivational situations around them. However, a recent clustered randomised controlled trial in the UK showed that adding a GP recommendation might not be able to decrease the inequalities disfavouring the deprived, the

study´s authors calling for more research on this topic in future (Raine et al., 2016a). Interestingly, however, a remarkable number of participants in our study suggested, when asked for suggestions to improve the current screening system, that there might be higher screening take-up if physicians and healthcare staff were more actively engaged in the screening process. For example, one participant put it in this way:

"Well, NHS is sending those kits, but people will put them aside if they don't want to take up the test. They don't want to mess up with the bowel movements. So, it needs people, someone, a GP, a nurse, to be standing there and telling them what they are going through and push them to do the test". (Female, 66 years old).

However, after a relatively short account of SDT and its contribution, one might raise the question of why a (linear-based) theory like SDT should be adopted, when the study was informed by a complex cases approach in which configurations of conditions are important. The reasons for such a decision are twofold. First, SDT gives a more structured and scientifically-sound basis to believe in the importance of motivation (or its lack) in CRC screening in Hull. Motivation acts as a control parameter in our study and we need a sound and relevant theory to understand and explain the reasons behind its importance as a determinant of (inequalities in) screening behaviour. Second, although STD has a linear and non-configurational approach, it gives primacy to the importance of relationships (between variables and cases) and context, and is close to complexity theory ideas in which the contextuality and relationality of systems (cases) are key to the emergence of features and behaviours.

5- Aversion

One of the interesting findings in the present study was the significant importance of aversion for screening among people of high socioeconomic status (Table 35 and 40 in chapter 4). In

fact, as the sufficiency analyses showed in chapter 4, lack and presence of aversion were a complete subset and superset of screening and its negation, respectively, among rich people in Hull. There might, however, be reasons for such a finding. For example, cultural codes about overall hygiene and hygienic medical instruments might be stronger among some rich people in Hull. For example, one of the participants who came from a rich neighbourhood and family background stated that:

*"I would certainly do the test if it was something nicer, like doing it once and not thrice. Something more hygienic. I mean if it was not touching, you know playing with, your bowel movement. I would do for sure then. It is not socially, family-wise, acceptable in its current status. Are they going to change it?"***(Female)**

These cultural codes then make these people more sensitive to the cleanliness of the screening kits and process so that they can decline the test if they feel aversive to it, even when motivated to do it. On the other hand, there is evidence that higher education levels are closely related with higher standards of personal and social hygiene (Hodgetts et al., 2007). As people of higher socioeconomic status were more educated in the present study, then such a relationship can be expected to be present. More importantly, this finding shows that emotions are sometimes stronger than rational thought and are able to prevent a behaviour even when a person, specifically an educated one, rationally knows that the behaviour is useful for their health. There is strong evidence for this in today´s psychology literature. For example, in a systematic review conducted by Reynolds and colleagues, it was shown that aversion and disgust towards FOBT are so strong that they make people avoid screening in almost all settings (Reynolds et al., 2013). When thinking in terms of translating this finding to practice, interventions designed for this group of people in Hull should be sensitive to aversion levels. More importantly, our study showed that there is a need for more sociological and cultural research to better understand this issue among these people in Hull in future studies.

6- What and Why questions

After relatively long discussions of socioeconomic status, motivation and aversion roles in screening, it may be a good moment to present the model of CRC screening that the present study has revealed. First, however, it would be useful to refer back to chapter 1 and see whether the study has managed to answer the "what questions" posed in that chapter. As shown throughout this chapter and the previous one, the study has successfully answered all those questions (questions 1 to 7), namely revealing the conditions and configurations conducive to screening and lack of screening among both socioeconomic groups in Hull. However, in addition to these "what questions", the study also attempted, to some extent, to examine the possible reasons behind the importance of these conditions and the emergence of such configurations in Hull. For example, we asked 'why motivation is so important in Hull', 'why aversion is so important among the rich', 'why logistic facilities are of importance', and 'why these configurations show up in this setting'. To be precise and honest, answering such "why questions" was beyond the scope of the study and we need more historical and sociological studies to answer them. Our study can be a starting point to develop investigations to answer such deeper questions in future. For instance, one might postulate that education level or even cultural factors might be behind the importance of configurations revealed in the present study, and open a new line of investigation to test this hypothesis.

7- Features of the developed model

The model of CRC screening developed in the present study has unique features that are different from other studies, especially Honein et al.'s meta-study, which our study used as a basis for design and comparison. First, very few people who took part in our study referred to fatalism. In fact, participants believed that cancer happens for a reason (e.g. lack of a healthy lifestyle), and even if it happens due to bad luck, there is a chance to prevent it and screening

is aimed at such prevention. This might be due to the relatively high level of awareness of CRC and its screening among the participants in Hull. Second, there was no mention of any specific cultural belief as a barrier among the participants. Third, physician recommendation had no place as a facilitator of screening in our study, although some participants suggested that physician involvement in the screening process can help people to take up screening. Fourth, logistic factors were among the main determinants of screening in our study. By logistic factors we mean all the factors related to the test's physical features (using, storing, handling, and posting). To the best of our knowledge, this study is one of the few studies (Lo et al., 2015b, Chapple et al., 2008, O'Sullivan and Orbell, 2004, Smith et al., 2016) in which logistic (practical) factors are raised as a determinant of screening and this could be one of the novel contributions of our study to the literature. Finally, motivation and not awareness sits at the centre of our model, and all other conditions configure with it to produce (or prevent) the screening. This is in contrast to Honein et al.'s meta-model which puts awareness at the heart of the model (Honein-AbouHaidar et al., 2016). In our study, awareness of CRC and its screening was relatively high and public media was the main source of people's information. Figure 31 illustrates the model produced in this study. This model should be looked at from a configurational perspective and be investigated in terms of different configurations of the conditions (and their negation) in the model which can produce (or prevent) screening. More importantly, all these configurations take place in a socioeconomic context, and this context is a very important part of the configurations as it can change the effects of configurations, producing inequalities in screening that are of salience in current public health.

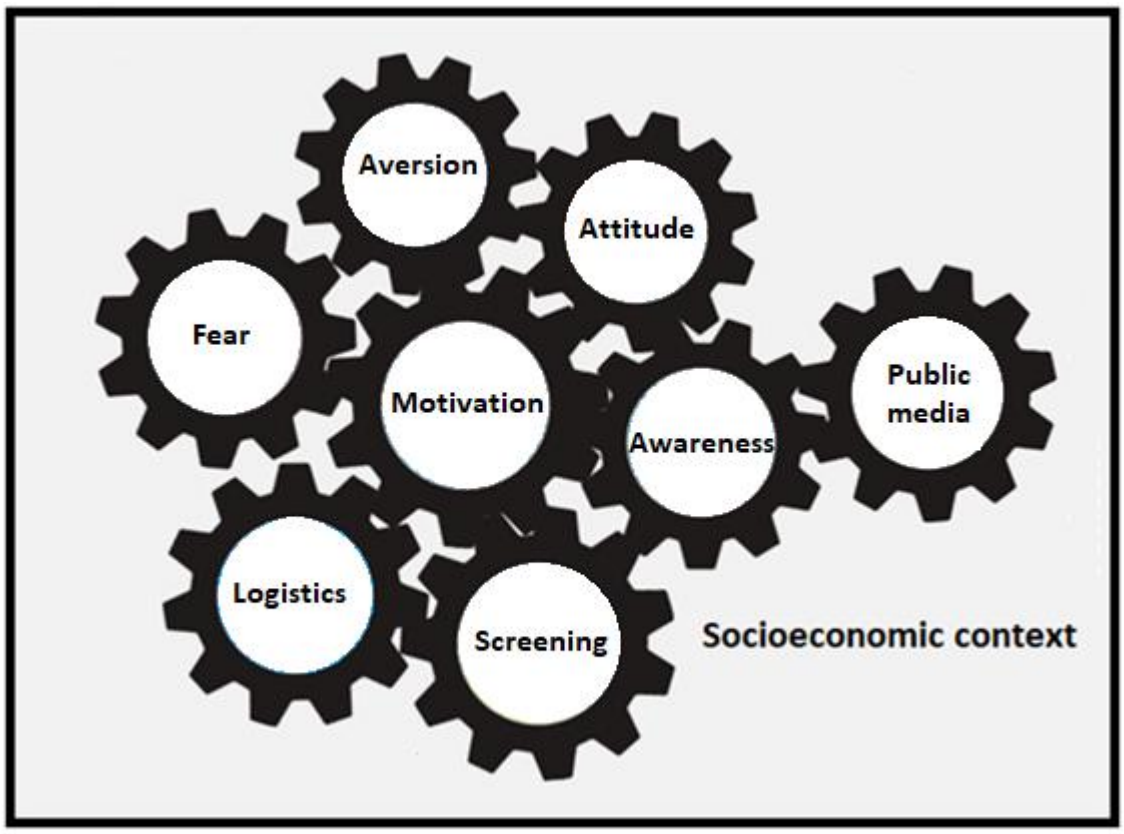


Figure 31. The model of colorectal cancer screening developed in the present study

8- Policy and intervention implications

The model developed in our study can be used in future policy-making and interventions in order to increase the rate of colorectal cancer screening and decrease inequalities. To date, there have been numerous interventions and trials to increase the rate of screening and redress inequalities in colorectal cancer screening (Duffy et al., 2017, Wardle et al., 2016). Some such interventions are as follows: physician endorsement (Damery et al., 2012), enhanced reminder systems in addition to the usual invitation (Raine et al., 2016b), patient navigation (Allary et al., 2016, Guillaume et al., 2017), narrative-based information leaflet (McGregor et al., 2016), gist-based supplementary information leaflet (Smith et al., 2013), simplified supplementary information leaflet (Smith et al., 2017), one-stop-shops (Bobridge et al., 2017), new test modalities (Groth et al., 2012), and motivational interviewing (Wahab et al., 2008). Each of

these interventions have been developed to address some of the main barriers (conditions) of screening. For example, gist-based, narrative-based, and simplified leaflets (interventions) mainly aim to tackle low levels of knowledge and literacy about colorectal cancer screening. Physician endorsement, reminder systems, and motivational interviewing interventions aim to address lack of external motivation. One-stop-shop and patient navigation interventions mainly aim to tackle logistic barriers. And finally, the introduction of new and user-friendly screening modalities aim to lessen test aversion and disgust. However, one of the main drawbacks of these interventions is their mono-directionality, i.e. they mainly try to cover and address one or two of the conditions/barriers, and do so for the entire population in the same way, without taking the complexity of barrier configurations and their distributions into account (Wheeler et al., 2018). The present study, however, showed that because of differences in configurations of conditions between people of lower and higher socioeconomic status, such mono-directional and one-size-fits-all approaches may not be the answer, and screening interventions and policies should be multi-pronged (Wheeler et al., 2018). To be precise, according to figure 27, there are 3 and 5 differential configurations that prevent screening among people of high and low socioeconomic status in Hull, respectively. Lack of motivation is present in all of these configurations, so motivation-boosting interventions should be a key part of any initiative regardless of socioeconomic status. Motivational interviewing, physician endorsement, and initiatives that can involve spouses (and family members/networks) in the screening could be examples of such initiatives. However, motivational interventions should be combined with other interventions, according to the importance of the corresponding conditions in the configurations. For example, if we consider the first configuration leading to lack of screening among people of high socioeconomic status (motivation*noaversion*nofear*ATTITUDE*LOGISTIC), it shows that apart from using motivational interventions, aversion and fear should also be addressed among these people as

well. Consequently, a new and more user-friendly test with narrative- and gist-based information should also be incorporated into the intervention. Similarly, if we take the third configuration of conditions among people of low socioeconomic status (motivation*noaversion*nofear*AWARENESS*ATTITUDE*logistic), motivational interventions should again be present, while interventions that address aversion, fear, and lack of logistic conditions should also be added. For example, a new user-friendly test that can be sent back/delivered to the healthcare system on the same day might be an option in this case. This kind of interventional reasoning applies to all configurations that are revealed across the social groups. This kind of thinking (reasoning), interestingly, is in line with an approach to interventions in public health known as "complex interventions" that have much in common with, and are influenced by, complexity thinking (science). The complexity of such interventions resides in the following features, which are in fact features of a complex system: a considerable number of interacting components, non-linear causal pathways, the complexity of the behaviour of intervention deliverers and receivers, the number of groups, hierarchies, organizational levels addressed, qualitative differences in outcome states, non-standardization, context-(configuration-)specificity, and the degree of flexibility in the intervention (Petticrew, 2011). All these issues show that we are in need of complex interventions, using configurational and complexity approaches, in the field of screening for colorectal cancer, although such a need has not been considered so far. Further research is required to allow the clear articulation of such interventions in the future (Petticrew, 2011).

9- Strengths and limitations

Despite the interesting findings and contributions detailed above, the present study has various limitations and strengths that should be borne in mind when reading and interpreting the findings. The first limitation is that it was not possible to include minority ethnic and migrant

groups in the study. In fact, invitations were sent to these people in order to have a high variation in the sample, but none of them agreed to take part and only people who were originally from England agreed to participate in the study. The second limitation of the study, considering its qualitative nature, is the number of people who took part in the study. In fact, our study was not able to reveal all the possible screening-related configurations of conditions in the city and it is therefore not fully representative. However, although narrow in -range, it is an in-depth study and a good first step to pave the way for future large-scale studies. For example, our model can be used for development of relevant questionnaires that can be used in future studies to reveal the status of screening determinants/configurations in large-scale quantitative studies in Hull and the UK. The limitations might affect the inclusiveness and representativeness of the revealed configurations and should be borne in mind in the interpretation of the findings, but the study also has a number of strengths. First, this is the first study on the determinants of colorectal cancer and its inequalities in Hull, to the best of our knowledge. Second, this is the first time that a complexity-(configurational) informed approach has been used to study colorectal cancer screening and its inequalities. This can have some positive effects on ways of thinking, research, interventions, and policy-making around screening behaviour in this city (context) and beyond. For example, following such a complex systems approach to screening, the next step of this study could be the application of other complexity-informed scientific methods, e.g. agent-based modelling, to simulate and compare the effects of different interventions (complex and simple), addressing revealed conditions and configurations, on the screening uptake rate and on screening inequalities in Hull. Finally, speaking generally, complexity-informed and innovative ways of thinking can be encouraged across all branches of public health, as we lack such an approach in almost all branches of public health where linear, solo-pathway, and reductionist approaches are dominant.

10- Conclusion

To wrap up, the current study showed that there are several configurations of conditions that can lead to screening or the lack of it in Hull. In complex systems terms, there are numerous screening attractors in the phase-state coordinates of the conditions in Hull. Moreover, such pathways are different among people of low and higher socioeconomic status, and the number of pathways to screening or its lack are higher among people of lower socioeconomic status. Interestingly, motivation is the most important (significant) condition influencing screening decisions in this city, regardless of socioeconomic status. Motivation was present in all of the configurations of conditions that influence screening. Therefore, motivation-focused interventions should be in the first line of interventions to increase screening rates and redress inequalities. Such interventions should address both the intrinsic (e.g. motivational interviewing) and extrinsic (e.g. physician engagement) facets of motivation to take up the screening. However, alongside special attention to motivation, due to the multiplicity of configurations, complex interventions should be designed and carved out to address the (other) conditions/configurations in each specific socioeconomic context within the city.

Moreover, alongside such implications for interventions, there are some important points that should be considered when public health practitioners aim to utilise the findings. The first point relates to extent of generalizability of our findings that come from an investigation of screening behaviour among a handful of people (30 cases) in Hull. As it was discussed in the methodology chapter, there can be some theoretical generalizations from our findings. To be precise, as this study focused on configurations of conditions (social processes) that led to screening behaviour in two specific contexts with different socio-economic fabric in Hull, the configurational, comparative, and contextual implications of our findings should be borne in mind when aiming to generalise the findings to a wider population in the city. Specifically

speaking, the findings are of great use in contexts where there is a chance that similar configurations for colorectal cancer screening behaviour are at work. For instance, there is a chance that some of the revealed configurations and processes are at work in Hull at large, or at least in some other parts of it, and these configurations can be a guide for interventions in those contexts as well. Prior knowledge of public health practitioners about different contexts in Hull can be of great help in making decisions about the extent of generalizability of our findings in that city. The second point relates to the way the ideas of configuration, complex causality, and co-production (of services/interventions) link to each other. Complex causality means that no single hand can solve the public health problems, since configurations are made-up of causes that link to different parts/levels/contexts of reality and are addressed by different organizations/stakeholders in a society. Therefore, stakeholders and participants from various organizations should come together to address the configurations in their whole. This matter applies to the colorectal cancer screening as well and relevant interventions should be co-produced by the several stakeholders (who are addressing and dealing with specific causes in each configuration) in order to tackle the configurations that produce the screening behaviour. So, co-production should be one of the guiding principles of intervention development for public health practitioners in Hull who want to use the present study findings to improve the colorectal cancer screening behaviour and redress the screening inequalities in this city.

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Appendices

(1) The R software codes used for analysis

"Outcome presence"

"Instalment of QCA package onto R console"

```
install.packages("QCA", dependencies = TRUE)

library("QCA")

datacrc <- read.csv(file.choose(), header=T)

datacrc
```

"Analysing necessity relations"

```
datacrcNR <- superSubset(datacrc, outcome = "OUTC", incl.cut = 0.9, cov.cut = 0.5)

datacrcNR
```

"Testing for sufficiency"

"Constructing the Truth Table"

```
datacrcTT <- truthTable(datacrc, outcome = "OUTC", show.cases = TRUE, sort.by = c("incl", "n"))

datacrcTT
```

"Boolean minimization"

"Complex solution"

```
datacrcSC <- eqmcc(datacrcTT, details = TRUE, show.cases = TRUE)

datacrcSC
```

“Incorporating logical remainders”

```
datacrcTT <- truthTable(datacrc, outcome = "OUTC", complete = TRUE, sort.by = c("incl", "n"))

datacrcTT
```

“Parsimonious solution”

```
datacrcSP <- eqmcc(datacrcTT, include = "?", rowdom = FALSE, details = TRUE)

datacrcSP
```

“Intermediate solution”

```
datacrcSI <- eqmcc(datacrcTT, include = "?", direxp = rep(1, 7), details = TRUE)

datacrcSI
```

“Outcome absence (negation)”

“Instalment of QCA package onto R console”

```
install.packages("QCA", dependencies = TRUE)

library("QCA")

datacrc <- read.csv(file.choose(), header=T)

datacrc
```

“Analysing necessity relations”

```
datacrcNR <- superSubset(datacrc, outcome = "OUTC", neg.out = TRUE, incl.cut = 0.9, cov.cut = 0.6)

datacrcNR
```

“Testing for sufficiency”

“Constructing the Truth Table”

datacrcTT <- truthTable(datacrc, outcome = "OUTC", neg.out = TRUE, show.cases = TRUE, sort.by = c("incl", "n"))

datacrcTT

"Boolean minimization"

"Complex solution"

datacrcSC <- eqmcc(datacrcTT, neg.out = TRUE, details = TRUE, show.cases = TRUE)

datacrcSC

"Incorporating logical remainders"

datacrcTT <- truthTable(datacrc, outcome = "OUTC", neg.out = TRUE, , complete = TRUE, sort.by = c("incl", "n"))

datacrcTT

"Parsimonious solution"

datacrcSPn <- eqmcc(datacrcTT, include = "?", rowdom = FALSE, details = TRUE)

datacrcSPn

"Intermediate solution"

datacrcSIn <- eqmcc(datacrcTT, include = "?", direxp = rep(1, 7), details = TRUE)

datacrcSIn

(2) Interview guide

Interview outline:

Introduction:

- I will explain that the purpose of the research is to better understand bowel cancer screening uptake among people living in Hull. These questions will act as a prompt to encourage the interviewee to speak about their experience.

    - May I have your name, age, education level, and occupation?

Main body of interview:

- Health history:

    - Have you had any illnesses or long-term health conditions (e.g. cancer)?
    - Has there been anyone among your family members/friends with cancer history?
    - Why do you think people develop cancer?

- Bowel cancer screening
    - Have you had any experience of bowel cancer screening?
    - Has anyone from your family members/friends had experience of bowel cancer screening?
    - What do you know about it?
    - How do you see it (perspective/attitude)? What is your reaction to it when you hear about it?
    - Do you know how your family members and friends see it?
    - Do you talk about bowel cancer screening with your family members and friends?

- Experience of specific potential (bowel) cancer symptoms
    - How much are you sensitive to your bodily functions? Do you take the abnormal symptoms seriously?
    - What do you know of potential bowel cancer symptoms? (Have not you observed any blood traces in faeces or had any abnormal stomach pain?)
    - How do you normally respond to those symptoms?
    - How your family members and friends respond to those symptoms?
    - Do you talk about such symptoms with your family members and friends?

- Health care contacts
    - Do you talk to your GP about your bowel symptoms?
    - What would you do if a healthcare professional/GP tells you that you need to go for bowel screening? How you will react?

- Neighbourhood conditions

- How do you define your neighbourhood? What is it like living there?
- Do you talk about cancer or cancer screening with your neighbourhood? If yes, what do you talk about? If no, what keeps you back not to talk?

- Media
  - What media do you use commonly?
  - What is your reaction to any reference to (bowel) cancer or cancer screening on the media?

Conclusion:

I will provide a summary of interviewee's perspective about CRC screening and request them to approve or supplement it with what might they have forgotten to add.