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Adverse childhood experiences and social and health outcomes in later life

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Adverse Childhood Experiences and Social and Health Outcomes in Later Life

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Submitted to the Faculty of Health Sciences

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Doctor of Philosophy

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Durban, South Africa

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Declaration

I, Sara Naomi Naicker, declare that this thesis is my own original, unaided work. It is being submitted for the degree of Doctor of Philosophy at the University of the Witwatersrand, Johannesburg, South Africa. It has not been submitted before for any degree or examination at any other university or institution.



SN Naicker

23 February 2023

Acknowledgements

I am deeply indebted to my supervisors, Professors Linda Richter and Shane Norris, for their guidance, support and patience throughout this work. They have been enormously generous with their time, knowledge, and networks. Working with Linda and Shane means more than access to their scientific expertise and technical skills; it leads to exposure to international experts, incredible learning opportunities, standards of work that are of the highest quality, and the belief that South African researchers and scientists are globally competitive – and I am grateful for this.

Thank you to my friends and colleagues, Andrea, Ridhwaan, Furzana, Kathryn, Chris, and Dumo for knowing when to ask about my Ph.D. and when not to, but always being available whenever I needed your advice.

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Thank you to Nazeer, for filling the space with laughter and playfulness, not taking anything too seriously, and telling so many people about this Ph.D., that not finishing wasn't an option.

And thank you to the Birth to Thirty participants, for giving so much of yourselves. Apart from the significant scientific advancements you've informed, many wonderful careers, including mine, have been built on your willingness to share.

Dedication

To Prof,

For always believing more than I did and fighting harder than I could.

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Thesis material and contributions

Together with my supervisors, I contributed to the conceptualization of the new ACEs data for this thesis. This data led to peer-reviewed publications that are part of this thesis and additional publications where the ACEs data has been used either as an exposure measure or controlled for as a confounder.

Peer-reviewed publications under this thesis:

I was principally responsible for conceptualizing each publication, developing analysis plans, conducting literature searches, data management, statistical analyses, and writing and submission of the manuscripts. Guidance on methods and data analysis techniques was provided by my supervisors and co-authors on the papers – all of whom reviewed the manuscripts. All three manuscripts have been published in peer-reviewed journals and are available under open access licensing (publications attached as Appendices 1-3). All co-authors, including my supervisors, have agreed to the scientific papers being presented in this thesis (Appendix 4).

1. **Naicker, S.N**., Norris, S.A., Mabasa, M. & Richter, L.M. (2017). An analysis of retrospective and repeat prospective reports of adverse childhood experiences from the South African Birth to Twenty Plus cohort. *Plos ONE,* 12(7): e0181522. https://doi.org/10.1371/journal.pone.0181522 (Appendix 1)
2. **Naicker, S.N**., Norris, S.A. & Richter, L.M. (2021). Secondary analysis of retrospective and prospective reports of adverse childhood experiences and mental health in young adulthood: Filtered through recent stressors. *eClinical Medicine, 40 (2021) 101094.* https://doi.org/10.1016/j.eclinm.2021.101094 (Appendix 2)
3. **Naicker, S.N**., Ahun, M.N., Besharati, S., Norris, S.A., Orri, M. & Richter, L.M. (2022). The long-term health and human capital consequences of adverse childhood experiences in the Birth to Thirty cohort: single, cumulative and clustered adversity. *International Journal of Environmental Research and Public Health, 19,* 1799. https://doi.org/10.3390/ijerph19031799 (Appendix 3)

Work on the first publication has also been included in a meta-analysis of prospective and retrospective measures of childhood maltreatment:

1. Baldwin, J. R., Reuben, A., Newbury, J. B., & Danese, A. (2019). Agreement between prospective and retrospective measures of childhood maltreatment: a systematic review and meta-analysis. *JAMA Psychiatry*, 76(6), 584-593. https://doi:10.1001/jamapsychiatry.2019.0097

Peer-review publications of which I am a co-author and where the ACEs data has been used:

1. Orri, M., Ahun, M.N., **Naicker, S.N.**, Besharati, S. & Richter, L.M. (2022). Childhood factors associated with suicidal ideation among South African youth: A 28-year longitudinal study of the Birth to Twenty Plus cohort. *Plos Medicine*, 19(3):e1003946. https://doi.org/10.1371/journal.pmed.1003946
2. Richter, L.M., Ahun, M.N., Besharati, S., **Naicker, S.N.** & Orri, M. (2021). Adolescent mental health problems and adult human capital: Findings from the South African Birth to Twenty Plus Cohort at 28 years of age. *Journal of Adolescent Health*. 2021;69(5):782-9. https://doi.org/10.1016/j.jadohealth.2021.04.017

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Abbreviations

ACEs	Adverse childhood experiences
ACE-IQ	Adverse Childhood Experiences International Questionnaire
AIC	Akaike's Information Criteria
BIC	Baysian Information Criteria
Bt10	Birth to Ten Study
Bt20+	Birth to Twenty Plus Study
Bt30	Birth to Thirty Study
CDC	Centers for Disease Control and Prevention
CI	Confidence intervals
COHORTS	Consortium for Health Oriented Research in Transitioning Societies
DPHRU	Developmental Pathways for Health Research Unit
GHQ	General Health Questionnaire
HIC	High-income country
HIV	Human immunodeficiency virus
IPV	Intimate partner violence
KIHD	Kuopio Ischemic Heart Disease Risk Factor Study
LCA	Latent class analysis
LMIC	Low-middle-income country
NCF	Nurturing Care Framework
OR	Odds ratios
SES	Socioeconomic status
SSA	Sub-Saharan Africa
SSABIC	Sample-size adjusted Bayesian Information Criteria
STIs	Sexually transmitted infections
WHO	World Health Organization

Abstract

Background: Well-established literature points to early life experiences and childhood adversities setting the foundation for health and development and influencing life trajectories. Nurturing, responsive caregiving in a safe and stable environment is associated with healthy, productive lives throughout adulthood. On the other hand, adverse experiences in childhood are associated with poor health and wellbeing, risky behaviour and reduced human capital. How this adversity is measured and the context in which it is measured may provide insight into the relationship between adversity and outcomes over and above what has been found in high-income countries.

Aim: The overall aim of this study is to examine adverse childhood experiences (ACEs) in a South African birth cohort. Specific objectives of the study include: a) developing prospective and retrospective profiles of ACEs in the sample, b) establishing levels of agreement between these two profiles of ACEs, c) estimating the prevalence and clustering of ACEs in this population-based urban sample, d) examining the associations between exposure to ACEs and a range of physical and mental health and social outcomes, and e) understanding the role that recent stress plays in the relationship between exposure to ACEs and poor outcomes.

Methods: This study uses a secondary analysis design using data from the longitudinal Birth to Thirty cohort. The cohort began in 1990 with the enrolment of 3,273 pregnant mothers and has followed the children born to these women for more than thirty years. The 10-item ACE Index developed by the CDC-Kaiser's ACEs Study was expanded to include five additional ACEs common in the South African context – chronic unemployment, violence in the community, household death, parent death, and separation from parents. Prospective profiles of ACEs were collated from data collected over the first 18 years of the child's life, initially reported by primary caregivers until age 11, then self-reported from ages 11 to 18. Retrospective profiles of ACEs were collected in young adulthood when the participants were 22 years old, along with an index of recent stressors. A series of human capital outcomes – those encompassing physical and mental health and psychosocial adjustment, were assessed at age 28. ACEs in the sample were conceptualized in three ways – as single adversities, such as physical or sexual abuse, cumulative adversity in the form of the ACE score, and clusters of adversity determined by their patterning. Cohen's kappa statistics and concordance rates were generated to establish the levels of agreement and consistency between prospective and retrospective reports of ACEs (timing) and between reports given by caregivers and children at age 11 (source). Descriptive statistics and latent class analysis were used to estimate the prevalence of ACEs and to explore the patterning of ACEs among participants. Logistic regression analysis explored associations between all three conceptualizations of ACEs and outcomes, disaggregated by sex. Mediation and moderation analyses were conducted to examine the influence of recent stress on mental health outcomes.

Findings: Comparisons between prospective and retrospective reports of ACEs show that there is relatively low-to-moderate agreement between timing and sources of reports of ACEs. Agreement varies depending on the adversity in question – with greater levels for objective

experiences such as parental death and lower levels for subjective experiences such as chronic unemployment. Differences in agreement were partly due to prospective and retrospective reports identifying largely different groups of people; those who only report high exposure prospectively, those who only report high exposure retrospectively and those that overlap. Using either prospective or retrospective reports, the prevalence of ACEs in this sample were high, although there were significant decreases in prevalence from prospective reporting to retrospective reporting. ACEs tended to co-occur, and where one ACE was reported, the likelihood of others increased. Clusters of ACEs split distinctively into high-low:dysfunction abuse categories; with one group likely to have low exposure, another with high generalized exposure to all ACEs, a third with moderate exposure characterized by household dysfunction and a fourth with moderate exposure driven by emotional abuse and/or neglect. All three conceptualizations of ACEs were significantly associated with poorer outcomes. Single ACEs such as physical, sexual and emotional abuse, and exposure to intimate partner violence, were independently and strongly associated with poorer outcomes in adulthood. Increased exposure to ACEs, or cumulative adversity, was also linked to poorer outcomes in a graded manner, with the likelihood of experiencing poor outcomes increasing along with exposure. The clusters with high levels of exposure to ACEs and moderate levels of exposure driven by emotional abuse were most at risk for poor outcomes. There were significant differences in exposure to ACEs, outcomes and the associations between the two by sex. Associations also differed for prospective and retrospective reporting with the strength of association varying depending on the outcome in question. Recent stressors were found to play a confounding role in the relationship between ACEs exposure and poor outcomes. Although recent stressors had a different impact on those who reported high ACEs exposure prospectively versus those who reported high ACEs exposure retrospectively. The influence of recent stressors on the mental health of those who reported high exposure to ACEs prospectively supported a sensitization model. In contrast, the role of recent stressors on the mental health of those who reported high exposure to ACEs retrospectively supported a stress inoculation model. This suggests two potential pathways for risk.

Conclusion: In combination and accumulation, it is demonstrated here that adverse experiences in childhood have an impact on health and wellbeing in adulthood. Specific individual ACEs can be teased out for their independent effect on outcomes, but the additive effects of multiple adversities lead to almost exponential increases in the risk for a myriad of negative physical and mental health and social outcomes. These findings provide important links from South Africa's context of high levels of violence in all forms and multiple hardships that families with large burdens of care endure, with little support, to many of the human capital outcomes on which productive, healthy and happy lives depend. Born at the dawn of democracy, with anticipation for opportunity, many of the children in this cohort were raised in contexts of adversity that may have been experienced as normative in those settings. Regardless of whether these experiences leave enough of a mark to be recalled later in life, the strain of cumulative adversity has had persistent and serious effects on their mental health, their ability to finish school, find a job and stay out of trouble.

Preface

Reflecting on the journey that brought me to this point, writing this final piece of my doctoral thesis, I had an amusing realization that things have come full circle. I am only 3 years older than the participants we study with such interest in the Birth to Thirty cohort, and growing up in South Africa we are acutely aware, some more than others, of the adverse conditions in which many people live. For those from disadvantaged backgrounds, the list of occupations your family will consider a 'success' is short – doctor, lawyer, engineer, accountant. The idea of a career in research only entered my cognizance when I began an undergraduate degree in psychology at the University of KwaZulu-Natal. By post-graduate level I was keenly aware that I did not have the stomach or patience to be a therapist; for those with seemingly trivial or '*first world problems'* I wouldn't have the patience, and for those with serious issues, I wouldn't have the heart to not take them home with me. Essentially, I did not want to deal with other people's problems. Yet, this thesis is about people's problems – all the many adversities that children, the most vulnerable in our society, face and the broad range of problems these create for our mutual health, happiness and wellbeing.

I felt a passion for helping people and the lure of research was that it put some distance between the horrors of what people on the ground in this field have to deal with but still allowed me to contribute meaningfully to society. Professors Linda Richter and Shane Norris are prime examples of this – their work has and continues to have important and tangible benefits both locally and globally. Having completed a Master's in Public Health Promotion, the opportunity to work with both Linda and Shane, in one of the most exciting and unique studies, was one I could not pass up.

At the time, my work centred on child, youth and family development, and increasingly I was immersed in the field of early childhood development. My interests were in the social determinants of health and more and more, as we used our research to inform interventions to promote health and development, it became clear that 'one touch' light interventions targeting individual risk factors were not effective and did not provide sustainable benefits. The ACEs field was all the rage and we realized that we were on the cusp of a unique opportunity. We knew that data from the longitudinal study collected prospectively over the childhood of participants matched the few questions in the ACE index, and that an upcoming young adult wave of data

collection would be an ideal time to collect retrospective data on ACEs. We would have two measures of cumulative adversity, one near contemporaneous, in an urban low-middle-income setting. The concept of cumulative adversity underpinning the ACEs was essentially a reimagining of the social determinants of health and wellbeing approach. We had been demonstrating through our work how the effects of violence, poverty and maltreatment in childhood, separately, were detrimental to children's health and wellbeing. Here was an opportunity to investigate whether these adversities occurred together and whether their cumulative effect on health and wellbeing was in fact broad-reaching and significant.

I began this work by arduously piecing together the enormous dataset that would house every piece of ACEs data from the antenatal period to young adulthood. The next step would be to compile two profiles of ACEs for each participant – one prospective and one retrospective. Then the equally complicated task of comparing the two profiles to identify consistencies and inconsistencies between them, with some interpretation of why differences occur. At this point, my motivation waned – the enormity of the task ahead coupled with ever present imposter syndrome got the better of me. I spent two years at Save the Children South Africa leading their research unit, driving implementation research to evaluate and improve on their interventions for vulnerable children. The time away brought me face-to-face with the adversity that so many families endure and served as a reminder that we still did not know the full extent of the problem, its pathways and consequences, and what we can do to effectively prevent and mitigate adversity.

Two years later, with support from Linda and Shane, the work I had started is complete in this thesis. However, as is the case with all research, new questions, ideas and hypotheses emerge in the process. In Chapter 1, I introduce the problem of adversity, the ACEs research to date and the gaps in our knowledge. In Chapter 2, I document as fully as possible the unique study comprising the Birth to Thirty cohort and the methodology followed in this work. Chapters 3-5 lay out the published studies conducted to answer the objectives set out in this thesis. Finally, Chapters 6 and 7 integrate these findings and draw conclusions. Limitations of the study and speculations on future research necessary to fill our gaps in knowledge and practice are provided.

PART 1: INTRODUCTION

CHAPTER 1: BACKGROUND & LITERATURE REVIEW

1.1. Background

Abuse, neglect and exposure to other traumatic experiences in childhood have long been linked to wide-ranging negative outcomes throughout the life course. Similarly, the concepts of cumulative adversity and toxic stress – the idea that taken together, the sum of negative experiences have an exponential impact on health and wellbeing, were relatively well known. However, in the mid-1990s the topic gained popularity when researchers from the Centers for Disease Control and Prevention (CDC) collaborated with Kaiser Permanente's Department of Preventive Medicine in the design of a large retrospective study to explore the role of adverse childhood experiences (ACEs) on social and health outcomes in adulthood. Considered the original 'ACEs Study', the researchers were able to associate ACEs with the ten leading causes of death in the United States and the study continues to demonstrate significant relationships between ACEs and social and health outcomes in later life [1-4].

The study has inspired similar research globally, a country-level ACEs questionnaire standardized by the World Health Organization (WHO) [5], an online questionnaire that allows users to calculate their own ACE score [6], and at least one Ted Talk [7]. Figure 1 shows the incredible surge in publications focusing on ACEs over a 20-year period. There are a number of explanations for this increase in public awareness around ACEs as a global public health challenge and why it has catapulted into popular science and public imagination. First is its relatively simple nature; the original ACEs Study developed an index of 10 childhood maltreatment and household dysfunction experiences before the age of 18 years, summed to obtain an ACE score for each participant, with the sum of these scores being linked to current health status and behaviour. Secondly, the study helped to advance the issue of child maltreatment in the field of medicine and public health policy [8]. Finally, the recognition of the connection of ACEs with costly chronic health conditions – and the economic advantages of their prevention – were appealing to policy- and decision-makers [9].

This chapter discusses how ACEs can be conceptualized, the established links between ACEs and a range of health and wellbeing outcomes, and the methodological challenges associated

with ACEs research. The overall aim, study objectives, research questions and hypotheses are also detailed.

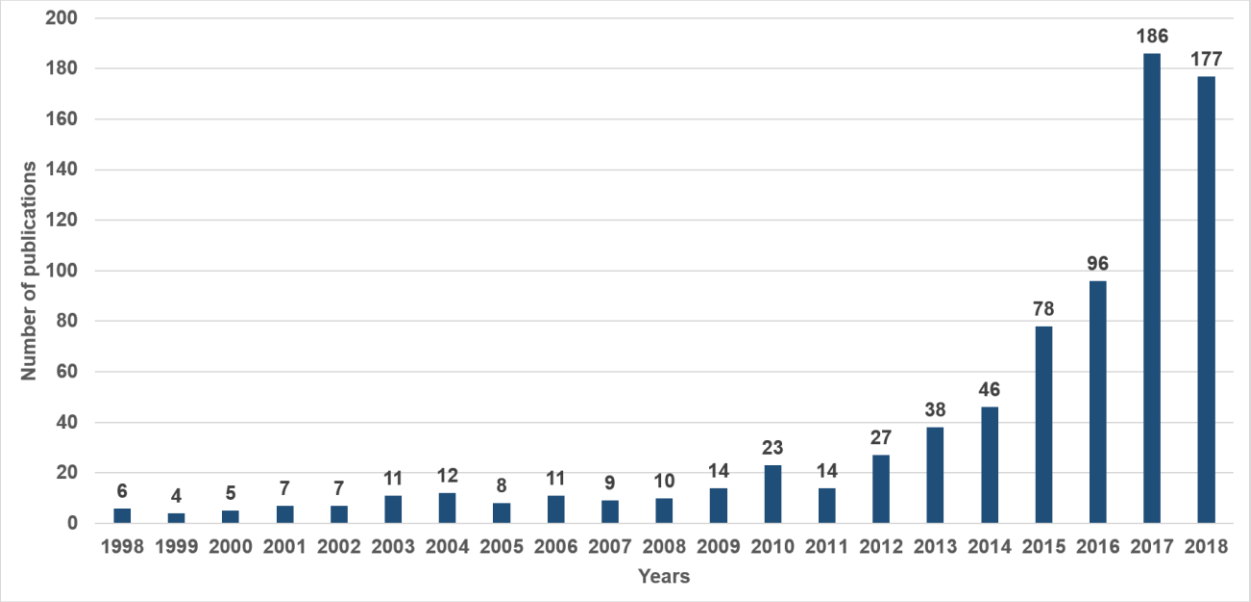


Figure 1: ACEs publications per year (1998-2018). Adapted from Struck et al 2021 [10]

1.2. Conceptualizing adverse childhood experiences

It is useful to situate ACEs within the broader context of child maltreatment and trauma. The ACEs Study identified ten adverse experiences (Figure 2), namely physical, emotional or sexual abuse, physical or emotional neglect, severe mental illness, substance abuse, intimate partner violence, divorce in the household, and an incarcerated member of the household. Over time, researchers have expanded this list of adverse experiences to include bullying, exposure to community violence, living in foster care, racism and poverty. The ACE index continues to be expanded as the importance of additional harmful experiences, whether at the household or societal level, are connected to health and wellbeing. From this perspective, ACEs can be considered a non-exhaustive list of childhood adversities, a broad term referring to circumstances or experiences that represent a serious threat

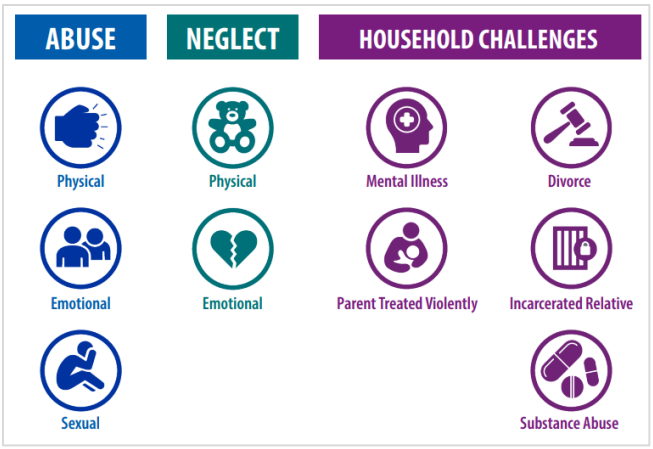


Figure 2: Adverse childhood experiences as originally defined in the CDC-Kaiser ACEs Study

to the health and/or wellbeing of children, in the present and into their future. Childhood trauma is one possible outcome of exposure to adversity, typically from defined sets of events; while toxic stress is the result of the psychological and physiological effects of chronic adversity experienced over time.

There are three ways that ACEs have generally been operationalized in research. The first is the cumulative ACE score or index, where each individual adversity experienced is summed in a binary fashion to produce a total ACE score. The usefulness of the ACE score, the number of ACEs reported, is that it enables the cumulative impacts of a variety of adversities on later life outcomes to be examined. One way to understand this cumulative property of ACEs is the notion of '*more is worse*' – that the number of different types of ACEs will be proportionate to the severity of the effect. This has been hypothesized as cumulative risk, or the accumulation of risk over time in an additive manner [11]. In the late 1970's, Michael Rutter constructed a *family adversity index* and demonstrated this effect on child psychiatric disorders [12]. In essence, environmental, socioeconomic and behavioural exposures may be compounded over time, resulting in accumulated risk.

While research has consistently shown that as the number of ACEs increase, so does the risk for a range of social and health problems, criticism soon followed that all ACEs could not be considered equal. This view emphasized the importance of not only identifying the number of ACEs to which an individual is exposed but their frequency and severity [13]. The second method used, although not frequently, is to weight ACEs based on the characteristics of exposure, such as age at exposure, frequency, duration, or the perceived severity of each individual ACE. In this case, ACEs that occur more frequently, are endured for prolonged periods of time or considered more severe, are weighted more heavily. Using this approach, Freidman and colleagues [14] demonstrated that the quantity of ACEs (the conventional ACE score) was linked to poor adult health outcomes. In addition, they categorized individual ACEs into meaningful subsets such as interpersonal or physical/sexual abuse; and finally they posited six age categories over childhood to represent significant periods of physical, cognitive and socioemotional development taking account the timing of ACEs. The key findings from their work are that timing matters less than frequency – at least for the cardio-metabolic conditions assessed in the study. Risk for poor adult health increased when ACEs were experienced in

multiple categories rather than within any single age category. They also found that different types of events were linked to different consequences. For women, physical and sexual abuse were especially predictive of heart disease, while overall adverse academic events (such as school dropout) were most strongly associated with poor health. The authors concluded that the best-fitting operationalization of ACEs for the three indicators of health used was the cumulative ACE score, and that each additional ACE increased odds of diabetes by 10%, heart disease by 18%, and obesity by 14%. Findings from this study are exciting and further research in other contexts and with additional outcomes that may be more sensitive to developmental periods is warranted.

The field also moved to the understanding that ACEs are inter-related [15]. For example, where childhood sexual abuse is reported, additional ACEs are often present [16]. To account for this, analyses have been conducted to create meaningful typologies of ACEs and, using theoretical knowledge, to rank these by severity. DeSantis and colleagues used factor analysis to categorize early adversity into *general trauma, trauma effects,* and *severe trauma,* with the latter two categories strongly linked to a physiological functioning indicator [17]. Using latent class analysis, Shin et al., were able to generate four typologies of ACEs from their data – low ACEs, household dysfunction/community violence, emotional ACEs, and high/multiple ACEs [18]. These were then examined against a range of outcomes of interest to assess which clusters of ACEs were most strongly associated.

The common theme across the different conceptualizations of ACEs and the broad range of physical health, mental health, social and behavioural outcomes assessed, is that ACEs have a persistent influence on health and wellbeing, however varying the impact.

1.3. Long-term, wide-reaching consequences of adverse childhood experiences

The domains of outcomes associated with ACEs in the literature cover the health and wellbeing of individuals, communities and society, as illustrated in Figure 3. A myriad of physical health problems have been linked to greater exposure to ACEs, including ischemic heath disease, cancer, chronic lung disease, skeletal fractures, and liver disease in the CDC-Kaiser ACE Study [19]. Additional studies have found similar associations between childhood adversity and other conditions, particularly age-related diseases [20-22]. Chartier and colleagues [23] looked at both the separate and cumulative effects of ACEs on adult health in a representative population

sample of just under 10,000 respondents. They found that exposure to each additional ACE, increased the odds for health problems. For instance, the odds of experiencing multiple health problems increased by 22% when one ACE was reported but rose to 48% when two were reported. The authors go on to state that their findings support the cumulative risk hypothesis, suggesting that it is the accumulation of a number of adverse experiences that is most detrimental to long-term adult health. Felitti puts forward two mechanisms through which ACEs could lead to disease [24]. The first is disease as a delayed consequence of some kind of coping strategy such as overeating, smoking, alcohol or drug use and risky sexual behaviours, which could lead to a variety of health concerns such as heart disease, lung cancer or diabetes [25]. The second is disease caused by chronic stress, which is mediated by physiological functions, and could lead to health problems such as chronic headaches and osteoporosis [3].



Figure 3: Range of outcomes linked to adverse childhood experiences

Research has also consistently shown a link between ACE exposure and mental health among both children and adults [3, 26-28]. The CDC-Kaiser ACE Study found a strong dose-response relationship between both individual ACEs and the ACE score and the probability of lifetime depressive disorders and recent depressive disorders [29]. This relationship was stronger for women than for men, and though attenuated by the presence of a mentally ill individual in the

household, remained significant. Other findings from the study demonstrated a dramatic 34.1 percentage point difference in the prevalence of having at least one reported suicide attempt between those who reported no ACEs and those who reported seven or more ACEs [30]. Exposure to ACEs has also been linked to personality disorders [31, 32] as well as affective and anxiety disorders [33-35]. Afifi and colleagues [36] projected the proportion of adult psychopathology at a population level that could be attributed to childhood physical abuse, childhood sexual abuse, and having witnessed domestic violence. Their study findings, based on the US National Comorbidity Survey, support the notion that a considerable proportion of psychiatric disorders and suicidality at a population level could be attributed to these three forms of childhood adversity.

Despite the abundant research linking early adversity to negative mental health outcomes in both childhood and adulthood, there is a much smaller body of work focusing on the effects of ACEs during young adulthood — the years following high school [37] — a period that for many young people presents a higher frequency of exposure to major life events [28]. ACEs may lead to poor adult adjustment if normal developmental processes are disrupted during sensitive periods [38], hypothesized as both the early years (typically under age 5) and in adolescence [39]. In their study assessing associations between lifetime exposure to ACEs and drug abuse, antisocial behaviour and depressive symptoms in a sample of high school learners, researchers found that eight out of ten ACEs were significantly associated with higher depressive symptoms and antisocial behaviour and nine out of ten of the ACEs reported on in their study were linked to drug use [37].

ACEs have also been shown to have strong links to social outcomes and behavioural risk factors for chronic disease including overweight and obesity [40, 41], physical inactivity [42], and smoking [1, 43]. Findings from the CDC-Kaiser ACE study show that as exposure to ACEs increased, so did the prevalence of and risk for alcoholism, use of illicit drugs, having greater than 50 sexual partners and having a history of a sexually transmitted infection (STI) [19]. Individuals in their sample with four or more ACEs were two and a half times more likely to have had an STI and had a seven times greater likelihood of experiencing alcoholism, compared to individuals who reported no ACEs. The Finnish Kuopio Ischemic Heart Disease Risk Factor Study (KIHD) is a large epidemiologic research project launched in the 1980s. Using

retrospective reporting and historical data from school records, the KIHD study has linked a history of ACEs to binge drinking in men [44]. ACEs may have long-term consequences on adult sexual behaviours which pose an increased risk for STIs [45]. A number of clinical studies show that women who have experienced child sexual abuse have a higher likelihood of being diagnosed with STIs, compared to women who have not experienced sexual abuse during childhood [46-48]. Physical abuse in childhood has also been linked to increased risk for STIs and risky sexual behaviours among adult women [49, 50]. The same is true for males, with physical abuse independently linked to risky sexual behaviour in both adolescence and adulthood [51-53]. Anda and colleagues report that for men in their sample, the likelihood of fathering a child with a teenager was positively associated with the frequency of childhood physical abuse; in addition, men who had experienced the most frequent physical abuse ('often' or 'very often') were 1.7 times more likely to be involved in teenage pregnancy then men who had not experienced this kind of abuse [54]. The same study reported that experiencing sexual abuse before the age of 10 increased the risk of involvement in teen pregnancy by 80% and experiencing sexual abuse involving violence or threats doubled the odds of fathering a child with a teenager. Similarly, the likelihood of involvement in teen pregnancy was associated with having a mother who was the victim of domestic violence [54].

Although there is substantial research on ACEs from high-income countries (HICs), data has only just begun to be generated from LMICs – including South Africa, most in the form of cross-sectional, retrospective studies [55-58], and a limited number of prospective studies [59-61]. Consistently across these studies, the prevalence of ACEs is higher than in HICs, with 73% of respondents reporting at least one ACE in Botswana [62], 75% in the Philippines [63], 77% in Honduras [64], 85% in Brazil [59], and 88% in South Africa [65] compared to 62% of respondents in the United States [66], and pooled prevalences of 24% and 23% in Europe and North America, respectively [67]. Nonetheless, the broad ACEs hypothesis, that exposures to adverse experiences in early life are associated with a range of poor outcomes, is supported in what LMIC research has been conducted. Among Sri Lankan men, greater exposure to ACEs was linked to IPV perpetration compared to no exposure to ACEs. Individual ACEs were also significant, with experiences of childhood emotional, physical and sexual abuse all linked to increased odds for perpetrating IPV in adulthood [56]. In Kenya, the likelihood of delinquent behaviour among adolescents increased significantly with greater exposure to adversity [55].

Poor mental health was also related to exposure to ACEs, notably depression in Botswana [62] and Pakistan [68]. Being exposed to more than three ACEs for adolescents in Indonesia was linked to increased likelihood of peer-violence perpetration, for both boys and girls [69]. In Malawi, reporting eight or more ACEs was significantly associated with depression, post-traumatic stress disorder, and worse self-rated health among adolescents aged 10-16 years old [70]. The Global Early Adolescent Study [57] assessed rates of ACEs among 10-14-year-olds in 14 low-resourced countries and found strong associations with depressive symptoms and violence perpetration.

In South Africa, ACEs have been similarly linked to poor mental and physical health and social outcomes either cumulatively or through individual adversities. Analyses of data collected in the Bt30 cohort showed that respondents reporting more than six or more ACEs were up to eight times more likely to experience psychological distress, and each individual ACE, apart from parental divorce and unemployment, independently predicted the risk for psychological distress independently [61]. In their prospective study, Cluver and colleagues [60] showed that the prevalence of suicide attempts was 1.9% among adolescents with no ACEs compared to 6.3% among adolescents reporting more than five ACEs, with similar associations with suicide planning and ideation. Findings from the South African Stress and Health study support these links; showing that two or more ACEs represented a twofold increase in risk of lifetime suicide attempts [71]. A study in the Western Cape also linked exposure to ACEs and deviant and antisocial behaviour [72].

Notwithstanding these ACEs-specific studies, research in South Africa, and other LMICs, tends to focus on single or a subset of adversities under the ACEs umbrella; analysis generally treats each adversity as an individual exposure but parallel trends are demonstrated. For example, Jewkes and colleagues [73] looked at how childhood emotional neglect, emotional abuse, physical neglect/hardship, physical abuse, and sexual abuse were related to a number of outcomes. They were able to link emotional neglect among women to depression, suicidality, alcohol abuse, and HIV infection; and emotional neglect in men to depression and drug use. Sexual abuse in childhood was also linked to depression among men and alcohol abuse among both men and women. Sexual abuse, emotional abuse and physical punishment were all associated with increased risk for HIV infection.

1.4. Methodological and measurement challenges

Several methodological gaps have to be addressed in the ACEs field, including the potential for confounding factors influencing both early adverse experiences and later outcomes. Individuals presenting with adverse health and psychosocial outcomes in later life may be more likely to report exposure to adverse experiences in their childhood [74]. Another challenge is the validity of reports of ACEs. Research on the long-term consequences of ACEs typically comes in the form of case-control studies where retrospective recall is necessary to elicit information from individuals who report having experienced some sort of childhood trauma and/or abuse, particularly since these individuals are typically not identified as children. This reliance on retrospective recall highlights how critical it is that these reports are non-biased, valid, and reliable. Whether retrospective recall can be considered to be reliable depends on a variety of factors. Some of these include memory, cognitive function during the experience, and later life experiences that could alter perception of the experience. The most obvious is one's ability to recall events that occurred in childhood. While memory deficits can occur over time, memory impairment can also occur as a result of stressful events experienced during childhood [75]. The degree of forgetting or recall is also determined by what has happened subsequently; whether events were discussed at all and if support or treatment were involved. Rothman and Greenland [76] suggest the aforementioned reasons tend to misrepresent exposed individuals as unexposed, resulting in bias towards underestimating the associations between ACEs exposure and outcomes; this finding has also been reported by others [77, 78].

Extensive research has tried to examine reliability in these reports. In their study assessing the reliability of retrospective reports of ACEs, Dube and colleagues [79] examined the responses of 658 participants of the CDC-Kaiser ACE Study collected in two waves during adulthood with an average time interval of 20 months between waves. Findings suggested that discordance between responses were uncommon and, when evident, were relatively small. A number of studies have found similar results in terms of the reliability of retrospective reporting even with the use of different measures to assess childhood maltreatment [80-83]. However, since the test-retest reliability analysis conducted on both response waves reported by Dube and colleagues [79] occurred in adulthood, their findings of good to excellent reliability in reports of ACEs cannot be extended to issues of consistency in reporting between childhood and adulthood.

In their review of the evidence regarding validity of adult retrospective reports of ACEs, Hardt and colleagues [84] argue that the best method to assess the validity of retrospective recall is to compare contemporaneous and retrospective accounts of childhood experiences. Problems with this include the fact that more often than not it is a parent or other person reporting instances of abuse as they occur and that only a very small number of cases are reported and documented. The authors conclude, after reviewing the evidence, that retrospective reports in adulthood of adverse experiences in childhood are adequately valid and where bias is concerned, it falls on the side of false-negatives rather than false-positives. They caution that the recall of experiences subject to wider interpretation, relying on judgement rather than objectivity, are less satisfactory in terms of validity than those associated with serious abuse, neglect and conflict [84]. One such example is the consistency in reports of early separations; reports of parental death and parental divorce remained consistent over time, but reports of other, more nuanced types of separations did not show the same levels of stability [85].

A range of methods can be applied to corroborate or support retrospective recall, such as additional measures of the incident being conducted at the same time, verification through official records and comparison with reports from others over the same period, but these are not without their own problems. Where there is prospective data, they generally comprise school records – often incomplete and with limited information on ACEs – or court records which are typically only available when the situation in childhood was extreme.

Although the broad concept of ACEs refers to adversity in childhood or before age 18, there are questions around sensitive developmental periods. Numerous prospective studies have looked at different ages of trauma onset and their impact on a variety of outcome measures at different time points in later life. Similarly, most research on the long-term consequences of ACEs have been conducted among older, middle-aged adults with little done in the years following high school and young adulthood [37]. However, there is still no definitive answer as to whether developmental age at trauma influences the type and/or severity of health and social problems experienced by maltreated ACE-affected children in later life [86]. Findings from a review of the enduring psychobiological effects of early adversity suggest that there is a non-linear relationship between developmental age and vulnerability to the consequences of adverse experiences [86]. For example, in utero trauma – such as growth restriction and prenatal alcohol exposure – is

often associated with slower development in childhood and adolescence. In early childhood, studies on the institutionalization of children from birth found that transition to family care before 2 years was associated with better cognitive, socio-emotional and motor functioning than later transfer to family care [87]. Another critical period appears to be around pubertal maturation, when the onset of gonadal hormone production influences stress reactivity. Individual stages of sexual maturation will then have different buffering effects against adverse experiences [88]. In the global LONGSCAN project, ACE exposure was unrelated to somatic symptoms at age 12 but was related at age 14; and at age 12, psychological abuse was most strongly associated with negative outcomes compared to at age 18, when sexual abuse most strongly predicted negative outcomes [89]. These findings emphasize the importance of assessing the implications of ACEs experienced at a specific developmental period on long-term outcomes and comparisons of this to ACEs exposure at other development periods. Such research will aid in design of better targeted interventions for prevention and response.

1.5. Conceptual framework

The bio-developmental framework (Figure 4) highlights the common early childhood roots of lifelong outcomes in learning, behaviour and both mental and physical health. The brain's architecture develops from a genetic blueprint. Environmental experiences influence the wiring of this neural circuitry and reciprocal interactions between the genetic predispositions and early experiences play a significant role in laying down foundations for learning, behaviour, and mental and physical health [90, 91]. Interactions between genes and the environment in the early years (even in the prenatal period) create biological 'memories' or patterns that are mediated by epigenetic modifications. These patterns form the foundations of healthy development of brain structure and function, as well as other physiological systems that influence biological functions, including psychological resilience, stress management, immunological responsiveness, metabolic and neuroendocrine regulation, and cardiovascular health [92].

The framework rests on the evolutionary premise that an immature organism 'reads' the available environmental characteristics so as to develop the capacity to adapt to it. Nurturing, fortuitous, stable and predictable early experiences will promote healthy brain development and positively facilitate other regulatory systems. Early experiences that are characterised by threat, uncertainty, neglect or abuse lead to over-activated stress response systems which consequently

can disrupt the developing brain circuity and alter stress responsivity, leaving the individual more vulnerable to chronic diseases [92]. In effect, significant adversity in early life precipitates physiological responses that offer short-term benefits to the survival of the organism, but in the long run the adverse effects on adjustment negatively impact mental and physical health [93, 94].

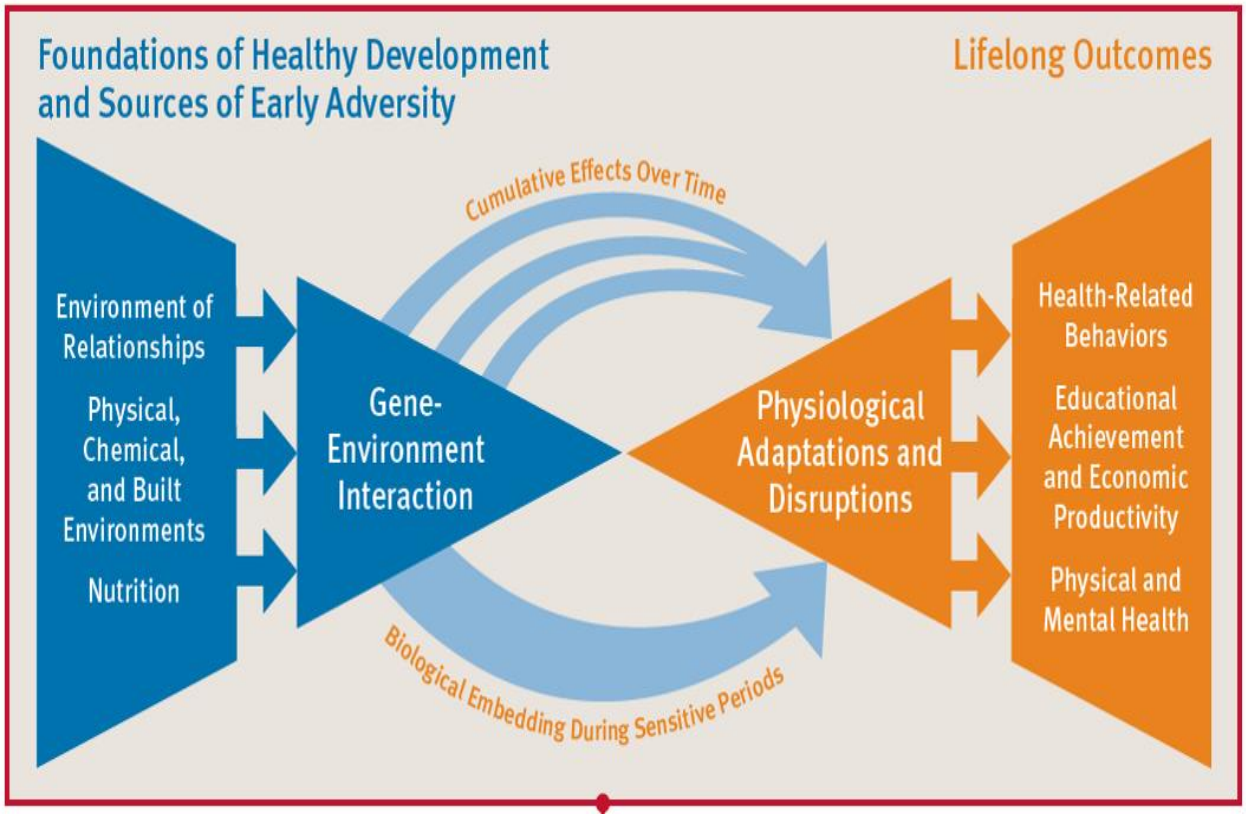


Figure 4: The biodevelopmental model of human health and disease [92]

The key elements of Shonkoff's [92] biodevelopmental framework fall into three domains; a) interactions between the foundations of healthy development and sources of early adversity, b) processes of physiological adaptation and disruption, and c) positive and negative outcomes in learning, behaviour and health. The first domain puts the foundations for healthy development and early adversity on three levels — relationships; the physical, chemical and built environment; and nutrition. The continuum of relationships within which a young child develops may range from nurturing, responsive caregiving to neglectful and abusive exchanges. Positive, stable and growth-promoting interactions with individuals within and outside of the family will safeguard against threats to healthy development.

Young children also require an environment free from neurotoxic exposures to, for example, lead and mercury, in addition to protection from other sources of physical injury. The safety of the early physical environment also extends to the surrounding neighbourhood and more broadly, to the social capital available to families with young children. Finally, appropriate versus poor nutrition is a critical area for healthy development and includes nutritious food that is both available and affordable, essential parent knowledge on appropriate feeding, and a balanced intake of macro- and micro-nutrients.

Leading on to the second set of domains in the framework, the experiences of children in each of these levels interact with their genetic predispositions to create psycho-physiological adaptations – when development is healthy, or disruptions – when it is not. The chemical impact induced by these experiences play a role in determining which genes are activated or expressed and ultimately how the brain and body develops. These are the biological mechanisms through which our relationships, physical environment, and early nutrition influence physiological adaptations and disruptions that go on to determine lifelong health and wellbeing. These mechanisms function in two ways, the first is through significant disruption due to adverse experiences during sensitive periods of development in the brain or other organ systems – for example, the time-sensitive effect of prenatal alcohol exposure. The second is the cumulative effect, or what can be called the biological 'wear and tear' caused by repeated experiences of adverse events, particularly if experienced within a general context of hardship. This weathering effect is due to the chronic stimulation of stress response systems in the body. The physiological responses include a range of mediating biological variables such as oxidative stress, inflammatory cytokines, telomere length, telomerase levels, and epigenetic profiles [92].

The third set of domains outlines the effect of these physiological adaptations and disruptions on adult outcomes in education, economic productivity, health-related behaviours, and physical and mental health. Positive early experiences are associated with healthy, adaptive physiologies. Adverse experiences are linked to dysfunctional systems consistent with compromised learning, maladaptive behaviour, illness, disability, and a reduced lifespan. Although the exact causal pathways are not yet clear, increasingly, evidence supports the idea that these adult outcomes are impacted by early experiences that can be addressed through interventions.

One of the advantages of the biodevelopmental framework is that it clearly highlights the opportunity and significance of intervening for those most vulnerable at the earliest age. Another equally important benefit, is its use in trying to understand individual variations in biological sensitivity to context; which may explain why some children thrive in spite of adverse conditions, and why specific interventions may work for some children and not others [95].

The Nurturing Care Framework (NCF), originally designed to cover preconception to age 5, has been extended to age 20, and conceptualises the critical factors during the periods of pregnancy, early childhood and adolescence that contribute to healthy development (Figure 5). At the core of nurturing care is a stable environment and behaviours that ensure good health and nutrition, protection from threats, opportunities for learning, and relationships that are supportive and responsive, surrounded by a facilitating environment of policies and services [96]. In the early years, young children are overwhelmingly at the receiving end of nurturing care inputs. With growing agency and autonomy, adolescents begin to shape their own relationships and environments [97].

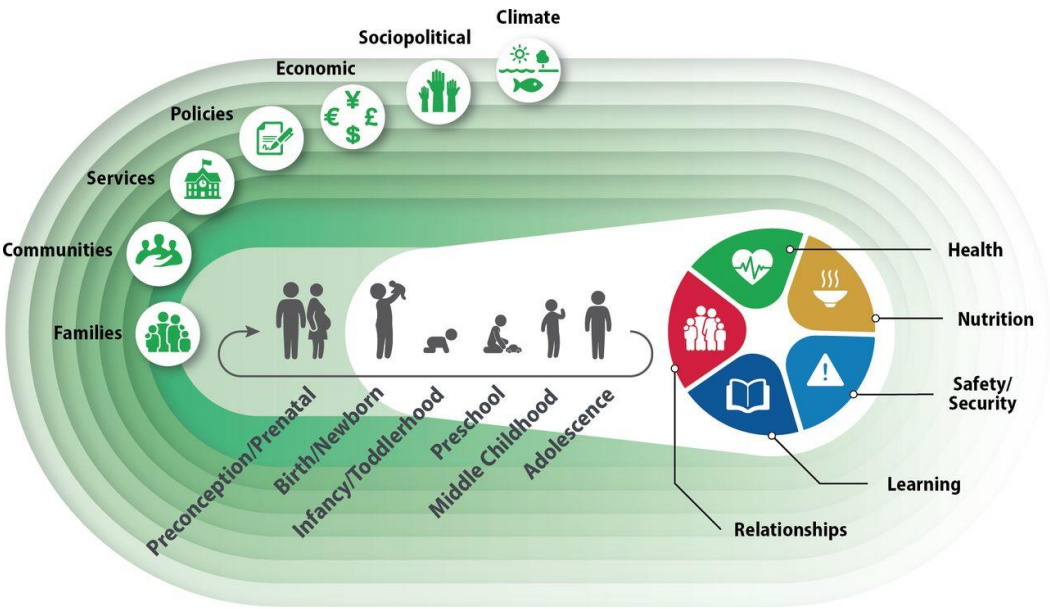


Figure 5: Nurturing Care Framework from conception to adolescence [97]

The NCF can be used as a guideline for implementation of multisectoral policies, services and programmes, from preconception to adolescence, that promote the health and wellbeing of children. It is particularly appropriate as a framework for understanding the risk and protective factors that contribute to the pathway from ACEs to poor health and social outcomes since it

promotes a safe and stable environment wherein exposure to ACEs can be mitigated by protective measures and children can be supported to reach their full potential as far as possible.

A conceptual framework specific to and coming directly out of the original CDC-Kaiser ACE Study is the ACE pyramid. The original ACE Pyramid (Panel A of Figure 6) was designed to assess the then 'scientific gaps' – shown with two arrows on the diagram – about the origins of risk factors for health and social outcomes in the two layers above the base of the pyramid. The CDC-Kaiser ACE Study had set out to answer the question, "if risk factors for disease, disability, and early mortality are not randomly distributed, what influences precede the adoption or development of them?". Through their work, core ACE researchers unpacked the relationships between ACEs and the prevalence and development of risk factors for health and social wellbeing across the life course.

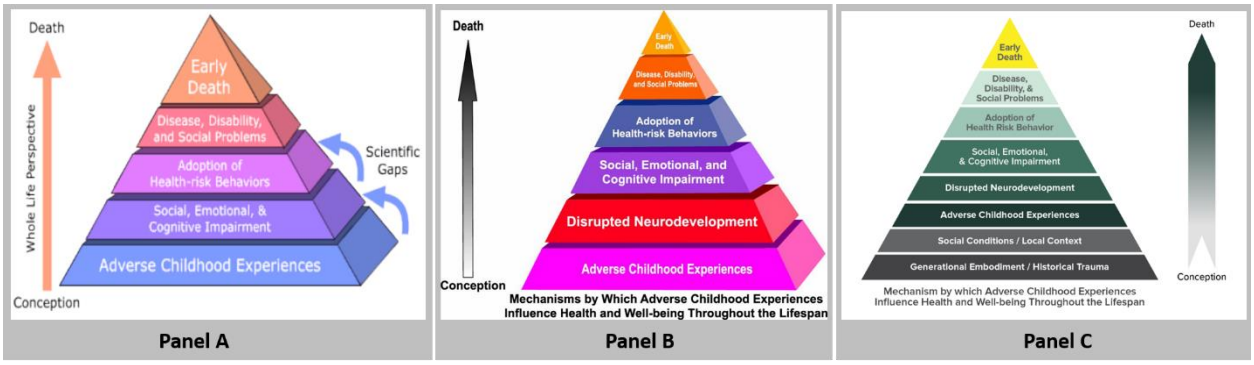


Figure 6: Three iterations of the ACE Pyramid as it was adapted based on findings

Over time, the ACE Pyramid was adapted to include a layer just above the base (Panel B of Figure 6) to account for the ways in which ACEs disrupt neurodevelopment through biological embedding. In Panel C of Figure 6, the most recent version of the ACE Pyramid includes two more layers just below "adverse childhood experiences" to account for the role historical trauma and social conditions play in determining exposure to ACEs. The model proposes that exposure to ACEs contributes to abnormalities in biopsychosocial systems, which then exacerbate risk behaviours, leading to the onset of poor health and social outcomes and eventually premature death [98]. ACEs are generally considered to have an intergenerational effect [99]. Through various behavioural and biological processes, what one generation experiences is transmitted to the next via, for instance, caregiving practices. For example, one longitudinal study showed how a mother's exposure to ACEs was associated with infant development at 12 months through biological and psychosocial pathways [100].

This study uses a life course approach drawing from the biodevelopmental, NCF and ACE Pyramid frameworks to assess the impact of ACEs on young adult outcomes. The conceptual framework below outlines these elements (Figure 7). The premise of the study is that ACEs will occur in a context founded on the interactions between genetics and the nurturing care environment. Reports of these ACEs can be elicited either prospectively or retrospectively and the shorter the time lapse, the greater the agreement between them. Through pathways of risk, these ACEs will have an impact on health and wellbeing outcomes. Recent stressors are added to understand the role of contemporary stress and control for its influence on outcomes, isolating the impact of ACEs.

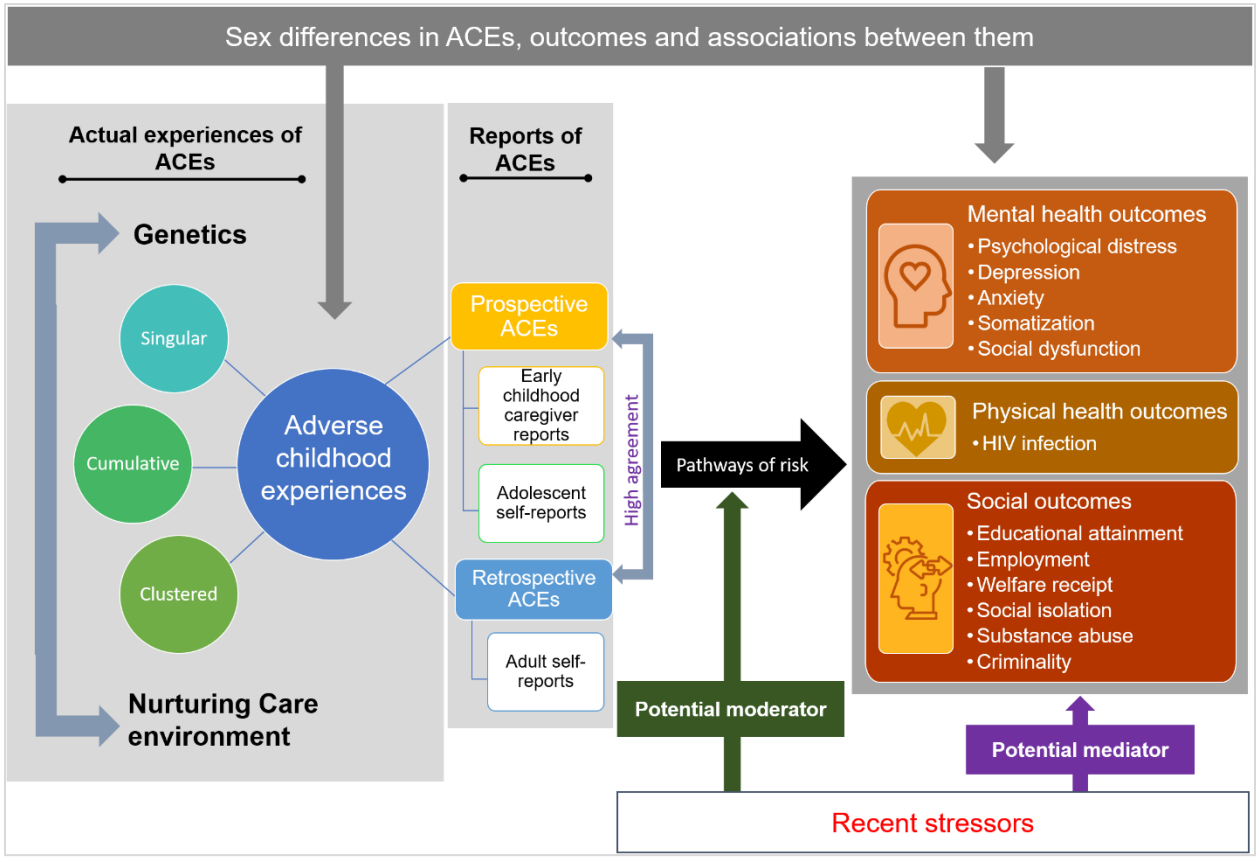


Figure 7: Conceptual framework

1.6. Research gaps, study objectives, research questions and hypotheses

This study has been designed to contribute to a number of research gaps and its objectives have been formulated with this in mind. The overall aim of this study is to replicate findings of the CDC-Kaiser Study in the Birth to Thirty (Bt30) cohort, with a number of advantages at hand. Firstly, using data from a population-based rather than an at-risk sample. Data from the large

prospective Bt30 birth cohort study, a design recommended when research aims to investigate the relationships between histories of abuse and subsequent outcomes [101], are used to develop ACE profiles. Many of the ACEs items have been put to the participants in some form from the earliest stages of the study. This makes available a dual prospective and retrospective sample – with reports of ACEs elicited from both the mother and the focal child prospectively and from young adults retrospectively – together with the collection of a wide variety of contextual variables. This provides a unique opportunity to not only test reliability of reporting from responses at various time points between childhood and young adulthood, but to also corroborate these self-reports with accounts of ACEs from caregivers. At a methodological level this deals with the problems associated with retrospective reporting and provides the ability to control for confounding variables.

The Bt30 study began at a critical point in South African history within a rapidly transitioning setting, one characterised by continued widespread poverty among the majority of people, rapid social and material changes and services stretched to breaking point. Conceptually, this is important in understanding the effect of ACEs in a context where relatively high levels of adversity are experienced in general or under normative conditions. Finally, the vast majority of evidence on ACEs and later life outcomes comes from HICs. There are few studies of this nature with a substantial sample set in LMICs and replication in the South African context is useful for expanding our understanding of the long-term effects of ACEs.

The study's objectives, as illustrated in Figure 8, and the research gaps they fill are listed below:

1. **Research gap**: Over-reliance on retrospective reports of ACEs in available literature; little evidence on the consistency between retrospective and prospective reports of ACEs and what implications these differences might have on the links between ACEs and outcomes.

   Objective: Develop prospective and retrospective profiles of ACEs for the Bt30 cohort and explore the consistency across the timing and source of these reports of ACEs.

2. **Research gap:** Little empirical evidence on the prevalence of ACEs in an urban South African sample and their patterning; without which unable to draw comparisons between high-income settings where adversity may be less prevalent.

   Objective: Explore the prevalence and patterning of ACEs to determine their co-occurrence and clustering.

3. **Research gap:** Little evidence of whether the relationships found in high-income settings between ACEs and outcomes hold true in low-middle-income urban South African settings; and how these relationships may differ when ACEs are measured prospectively or retrospectively.

   Objective: Examine the relationships between retrospective and prospective ACEs and a range of social and physical and mental health outcomes in the cohort.

4. **Research gap:** Unclear what role contemporaneous stress plays in the relationship between ACEs and outcomes, particularly in high adversity settings.

   Objective: Explore the potential role of recent stressors in the relationship between ACEs and health and wellbeing outcomes.

5. **Research gap:** There are sex patterns in exposure to ACEs and in the distributions of outcomes, although this has not been illustrated in relation to how ACEs may differentially lead to poor adult outcomes for women and men.

   Objective: Identify sex differences in exposure to ACEs and related associations with poor outcomes.

The specific research questions and hypotheses that guided the study were:

1. What are the levels of consistency across prospective and retrospective reports of ACEs provided by a) caregiver, b) adolescents and c) young adults?

   Hypothesis: There is a greater degree of consistency between prospective and retrospective reports of ACEs in a young adult population compared to low to moderate levels of consistency displayed in the literature which focuses mainly on retrospective reports collected in middle-age or later.

2. What is the prevalence of ACEs in the sample, across time points and sources, and how do individual ACEs cluster?

   Hypothesis: The prevalence of ACEs is higher in the sample compared to studies conducted in high-income settings. There are also clear patterns of clustering of ACEs in the sample.

3. How are prospective and retrospective reports of ACEs differentially linked to social, physical and mental health outcomes and can one type of report be considered more reliable?

   Hypothesis: Both prospective and retrospective ACEs are linked to poorer outcomes, with the risk for poorer outcomes increasing in a grader manner. Given the issues with retrospective recall, associations between prospective ACEs and poor outcomes are stronger, advocating for the use of prospective or contemporaneous measures.

4. Do recent stressors measured contemporarily play a mediating or moderating role in the relationship between ACEs and poor outcomes?

   Hypothesis: Due to stress sensitization produced through exposure to high ACEs, recent stressors mediate or moderate the relationship between ACEs and poor outcomes.

5. Are there gendered patterns of exposure to ACEs and their links to poor outcomes?

   Hypothesis: Given the literature on ACEs and outcomes, females and males will experience different levels and types of ACEs and vulnerability to poorer outcomes.

In summary, the Bt30 data is especially valuable in terms of the amount of data available on ACEs at different time points, as well as relevant contextual factors and a wide range of outcome data. This provides an opportunity to carry out a modified version of the CDC-Kaiser ACE Study in the South African context using birth cohort data that allow for the controlling of a range of confounders.

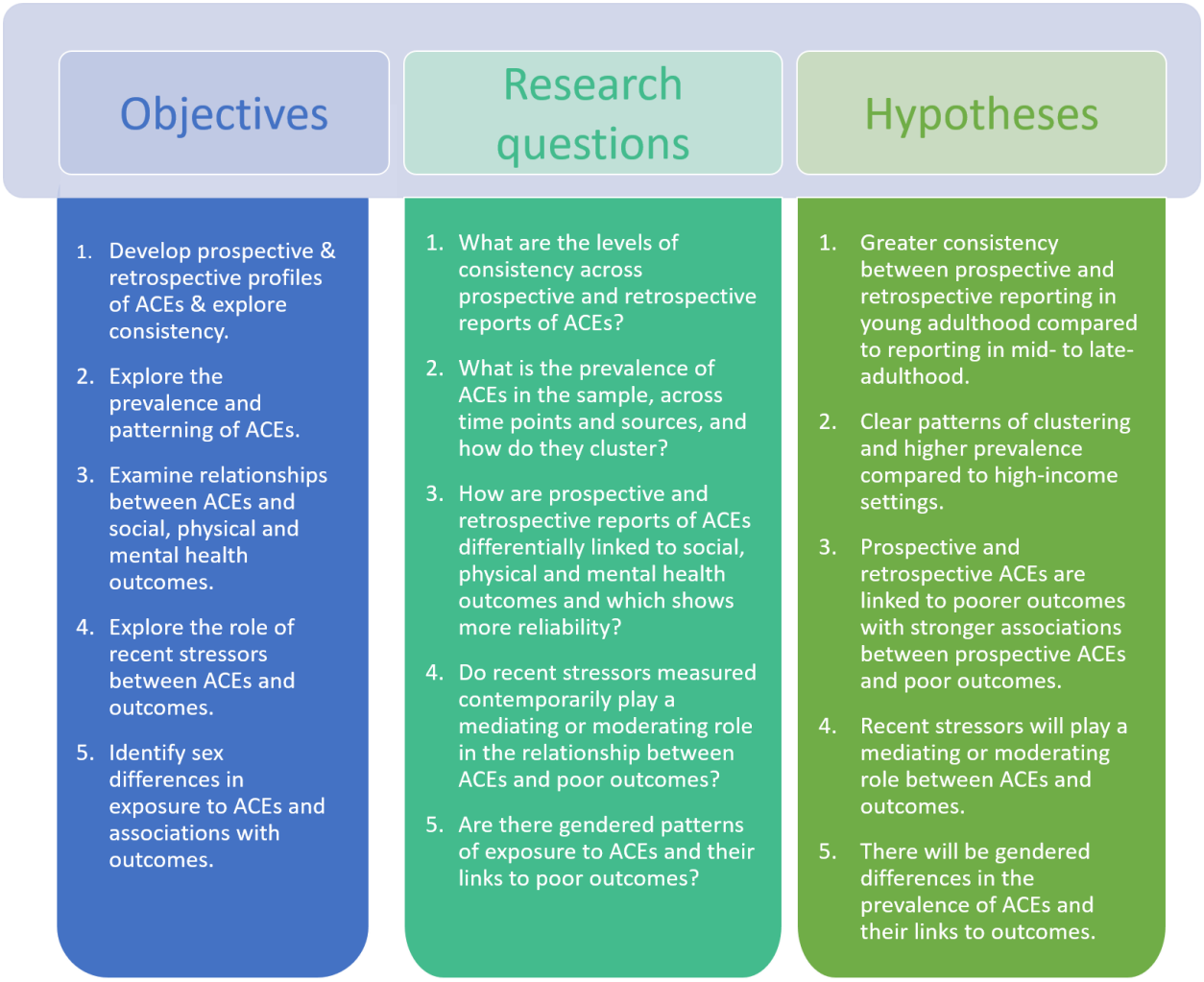


Figure 8: Summary of objectives, research questions and hypotheses

CHAPTER 2: METHODS

This chapter summarizes the methodology in two parts; the first is the methodology of the Bt30 cohort study, the umbrella project under which this sub-study was conducted. Following this, the methodology for this piece of work – referred to as the Bt30 ACEs Study, will be detailed.

2.1. The Birth to Thirty Cohort

The Bt30 study began as Birth to Ten when prominent researchers in South Africa were funded to carry out a birth cohort study in Soweto-Johannesburg to follow the development of urban children in South Africa. Coincidentally, this group of children were the first cohort to be born in democratic South Africa with the abolition of *Apartheid* on the horizon and the release of Nelson Mandela from prison just 7 weeks prior to enrolment. They entered into a context characterised by notable social and political change [102]. The prospective longitudinal birth cohort design was preceded by pilot studies in the late 1980's, with recruitment into the study sample between April and June 1990. The study took an intergenerational lifecourse approach, assessing pregnant women and their in-utero children, transitioning to focus on the children as the main participants over time. Collections of cross-sectional and smaller longitudinal sub-studies – of which this study is an example – make up the larger core study through the steady source of multidisciplinary researchers working on various topics.

Birth to Ten evolved into Birth to Twenty+ as the 10-year follow up was completed and the study was set to continue for a further decade. Having begun during the antenatal period, collecting information on pregnancy and birth, the multidisciplinary study went on to amass data on a wide range of domains. These include, but not limited to, poverty, access to healthcare, nutrition, childcare, growth and development, cognitive functioning, school performance, food intake and dietary information, parental supervision, body composition, bone mineral density, pubertal development, sexual and reproductive behaviour, substance abuse and violence. Apart from the abundance of socio-demographic, psychosocial and behavioural data, several biomedical markers and physiological measures were collected, including body composition, insulin resistance, cortisol, and bone density. Reaching is third decade, the study has been rebranded as Birth to Thirty and remains the largest and longest running birth cohort in Africa and since the first birth to a participant in 2005, the scope has expanded to include a third generation.

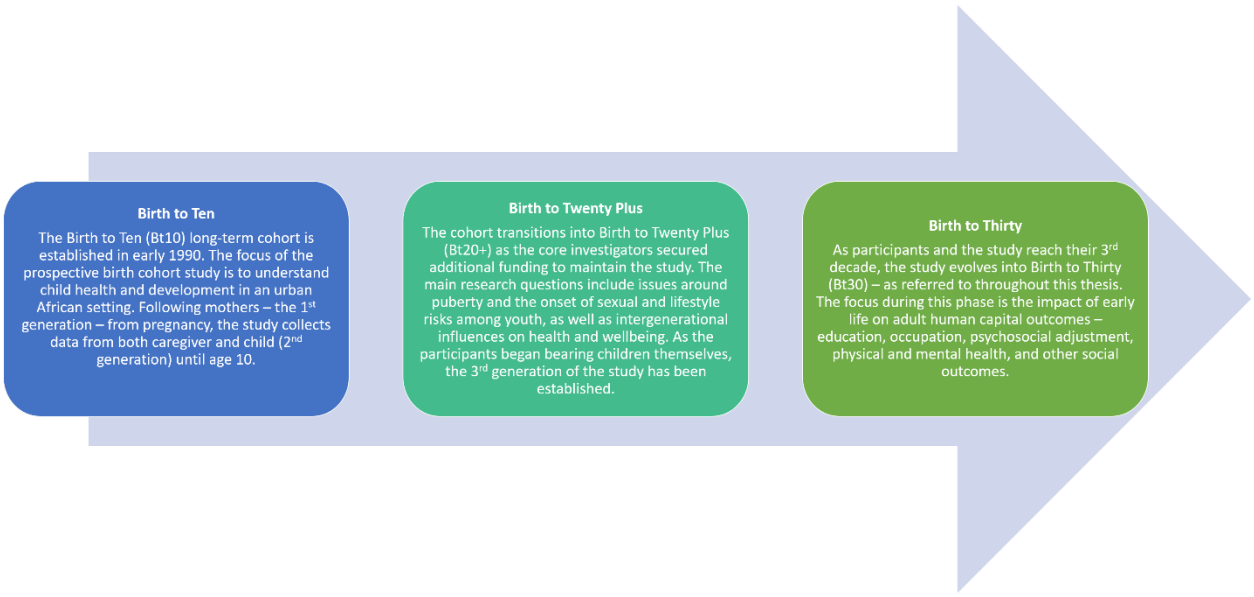
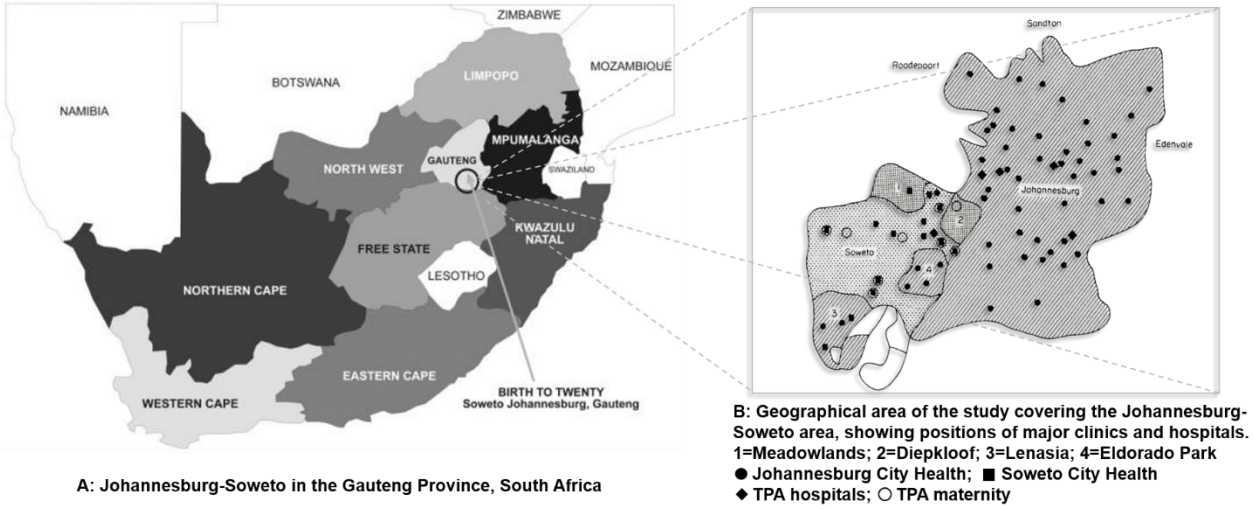


Figure 9: Evolution of the Bt30 Study

2.1.1. Study setting

Bt30 is set in the Gauteng province of South Africa, shown in Panel A of Figure 10. Panel B displays the geographical boundaries of the Soweto-Johannesburg area from which the sample was recruited. The study setting parameters comprised a population of approximately 3.5 million from the suburbs of Johannesburg-Soweto, as well as the suburbs of Diepkloof, Meadowlands, Dobsonville, extensions 1-7 of Lenasia, Eldorado Park, Coronation, Riverton and Klipspruit; covering about 200 square kilometres [103, 104]. The Soweto-Johannesburg metropolis can be characterized as South Africa's largest and most dense urban environment [105].



A: Johannesburg-Soweto in the Gauteng Province, South Africa

B: Geographical area of the study covering the Johannesburg-Soweto area, showing positions of major clinics and hospitals. 1=Meadowlands; 2=Diepkloof; 3=Lenasia; 4=Eldorado Park
● Johannesburg City Health; ■ Soweto City Health
◆ TPA hospitals; ○ TPA maternity

Figure 10: Study setting. Panel A source: Richter el al 2007 [102]; Panel B source: Yach et al 1991 [103]

In the late 1980s this area included about 400,000 informal housing units [104]; over time new townships were created across the north-west of Soweto with lower levels of servicing and a relatively poorer population [106]. Even at that period, the socio-economic status (SES) and living conditions in the Soweto-Johannesburg area were heterogeneous, giving rise to even greater disparities today. Table 1 illustrates these differences in a profile of eight Soweto townships [106]. The timing of the cohort, at the transition to democracy, meant the cohort could act as a microcosm of the socio-political transformation unfolding [105]. A balance was struck between a large enough sample for generalizability and a range of exposures with a cohort size that could be managed logistically [104]. The prospective longitudinal birth cohort design remains the gold standard for approaches seeking to understand, describe and explain developmental processes and change.

Table 1: A representation of socio-spatial differentiation: a profile of eight Soweto townships, 2011

	Dobsonville	Orlando East	Dube	Jabavu	Bram Fischerville	Kliptown	Protea Glen	Protea South
Population	40,328	68,210	18,123	45,128	14,008,	7,548	75,634	18,823
Average household size	3.4	3.0	3.3	4.0	2.8	4.7	3.2	3.5
% households in backyard shacks	22.2	28.5	1.6	11.3	26.0	3.0	0.3	10.5
% household in informal settlement	1.0	0.4	0.2	0.5	0.0	29.0	0.3	59.7
% households owning property	36.8	20.1	44.5	48.0	24.0	13.0	79.0	30.0
% Of non-SA citizens	7.1	10.0	4.8	6.6	11.4	8.7	4.3	14.4
Dominant first language	Setswana	isiZulu	isiZulu	isiZulu	Various	Afrikaans	Various	Xitsonga
% individuals aged 20+ with higher education	7.8	5.8	11.1	5.6	3.3	7.5	24.3	5.6
% population aged 15 to 34	40.2	36.1	41.7	39.2	44.2	40.1	39.7	44.4
% economically active age group and employed	44.5	38.4	41.3	33.5	44.1	42.3	55.3	41.2

% households with annual income below r38,400	64.1	70.6	64.0	65.8	72.0	61.0	26.2	88.1
% households with piped water in yard	97.0	98.0	91.0	99.0	97.0	54.0	99.0	71.0
% households with electricity	99.0	99.0	90.0	98.0	96.0	50.0	99.0	32.0
% households with regular refuse removal	100.0	99.0	97.0	100.0	96.0	97.0	99.0	84.0
% households owning a car and a computer	6.3	5.1	11.1	6.4	16.0	12.0	25.8	5.4

Adapted from Harrison et al 2014 ; Source data Stats SA (2012)

2.1.2. Study participants

The Bt30 sample consists of all single-birth children born within a 7-week enrolment window to mothers residing in Soweto-Johannesburg. Mothers were recruited at public clinics and must have remained in the area up until the child reached 6 months of age. The sample totalled 3,273 children, 50% with which the study is still in contact. Children and families are tracked throughout the Gauteng province. In terms of population group,[1] the sample comprised 78% African, 12% Coloured, 4% Indian and 6% White participants; a profile representative of the South African population which, at the time, had a slightly higher (9.2%) proportion of White individuals. White participants were under-enrolled as described in previous papers [98]. Table 2 shows the characteristics of the Bt30 sample.

Table 2: Demographic characteristics of the Bt30 cohort at baseline (N=3,273)

	Frequency	**Percent**
Population group		
African	2,568	78%
White	207	6%
Coloured	383	12%
Indian	115	4%

[1] Race and 'population categories' used in the Bt30 study are those that were defined by South African Apartheid government. Although they do not reflect genotypic, phenotypic or geographical origins of individuals, they do function as indicators of the influence of social and political forces at play in South Africa, particularly in the early years of this study and the participants' lives. See Ellison and de Wet for a commentary on "the use of 'racial' categories in contemporary South African health research" [107. Ellison, G.T. and T. de Wet, *The use of 'racial' categories in contemporary South African health research. A survey of articles published in the South African Medical Journal between 1992 and 1996.* S Afr Med J, 1997. **87**(12): p. 1671-9.].

	Frequency	Percent
Maternal age		
<17 years	92	3%
17-19 years	392	12%
20-38 years	2,692	82%
39+ years	95	3%
Residential area		
Soweto, Diepmeadow	1,158	65%
Suburban Johannesburg	298	17%
Former Indian/Coloured areas	254	14%
Inner city	68	4%
Maternal marital status		
Single	1,787	55%
Civil/traditional marriage	1,057	32%
Live together	259	8%
Divorced/widow	45	1%
Not known	23	1%

2.1.3. Data collection

Data has been collected across 23 points in the span of the study. Some rounds of data collection may include special interest variables but consistently collected data include demographic, socioeconomic and household information, community and school environments, health and nutrition, childcare, growth and physical activity, education and cognitive development, risk behaviours, and anthropometric and physiological measures [105]. With the exception of the last two adult data collection waves, caregiver and child data have been collected at each time point, with additional father data at age 15 year. Figure 11 illustrates the data collection waves over the lifespan of the cohort, including participants assessed at each point.

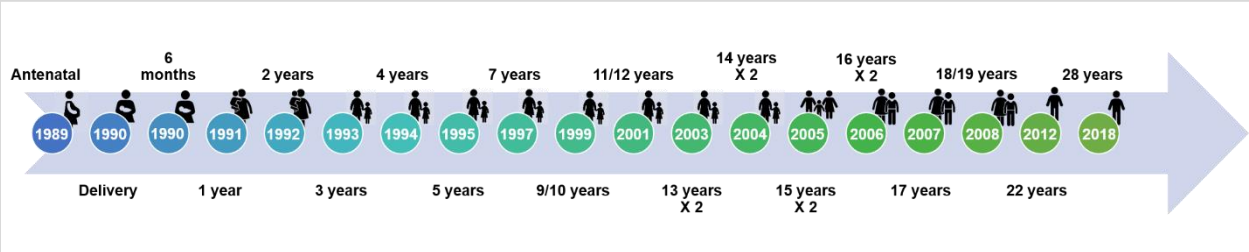


Figure 11: Timeline of data collection in the Bt30 cohort

Given the range of types of data collected, a number of different techniques were used. For the collection of physiological measurements and biomarkers, appropriate technologies and interviewer-administered assessments were applied. For the psychosocial and demographic data collected, caregivers provided reports for themselves and their children up to child age 11. From age 11, children in the cohort self-reported either through interviewer-administered

questionnaires or with the assistance of a trained interviewer; the latter became more common as children grew older. By age 15, data was collected from participants through the use of audio-assisted computer methods with staff available if help was needed. This technique allowed participants to listen to the pre-recorded questions using headphones and enter their responses via a keypad or touchscreen.

Attrition in the cohort mimicked similar rates and trends in other longitudinal cohort studies [108], dropping to over 50% at the 9/10 year wave but improving to 36% at the 15 year wave when additional resources were applied to trace those lost to follow-up [102]. At the 22-year wave, 1,636 participants (50%) were surveyed and 1,396 (43%) at the 28-year wave. Rates of attrition in the cohort are displayed in Figure 12. Analysis of attrition and retention in the cohort has revealed the two main reasons to be child or caregiver mortality (2% by age 16) and family movement to either an unknown, and untraceable, location or out of the study area [109]. The Bt30 cohort is highly mobile, not uncommon to children and families elsewhere in South Africa, and particularly in and out of urban areas. A quarter of participants in the cohort register an address change within any given data collection wave, which is just slightly higher than national census estimates of youth movement in the previous 10 years (15-24-year-olds at 19% in 2011) [110]. Patterns of residential mobility within the cohort have been published [111]. Despite these levels of attrition, the regularity of data collection waves meant that when data is grouped into 4 age or life stage categories – antenatal to 5-years-old, 7-14-years-old, 15-18-years-old, and 22-28-years old – 98% of the sample have attended at least one visit in each of these categories.

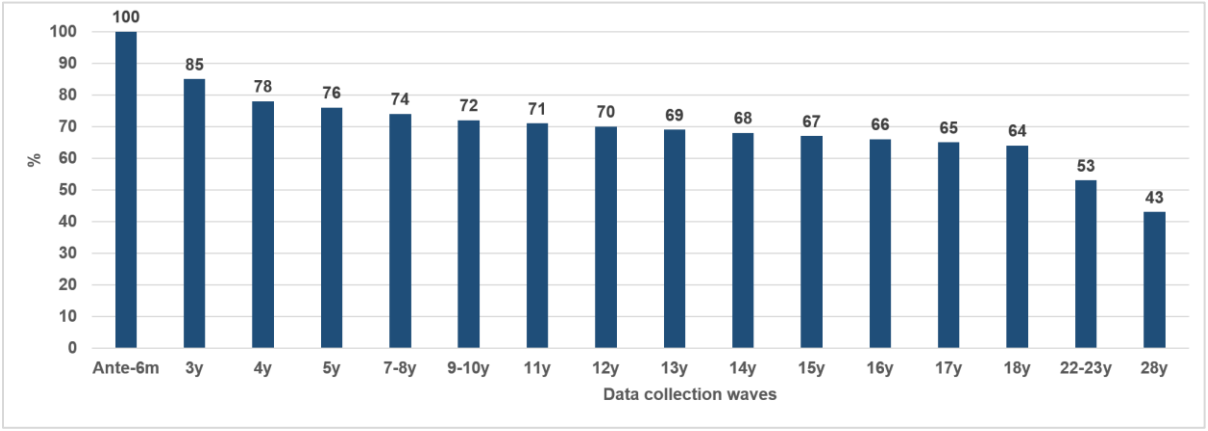


Figure 12: Attrition rates across the Bt30 cohort

2.1.4. COHORTS

In 2006, Bt30 joined the Consortium for Health Oriented Research in Transitioning Societies (COHORTS). This network comprised the five longest running birth cohort studies in low-middle-income countries – Brazil, Guatemala, India, the Philippines, and South Africa. COHORTS combined the data of the 5 cohort studies and aimed to draw conclusions about early life and adult outcomes among the 11,000 participants in the total sample [112]. The 28th round of data collection in the Bt30 study was conducted under the COHORTS collaboration.

2.2. The Bt30 ACEs Study

Methods relevant to this thesis are detailed in the rest of this chapter.

2.2.1. Study design

This study uses a secondary data research design. Data collected since pregnancy and to date in Bt30 has been analysed. Secondary analysis of longitudinal data has demonstrated value in the fields of public health and social science, for both policy and practice, globally but specifically in South Africa in terms of the findings from Bt30. Primary research processes were utilized at the 22-year data collection wave when the researcher was part of the study team. Although data has already been collected with secondary research, extensive work is done to review all questionnaires and data potentially useful to the research questions; cleaning, collating and transforming data; and assembling datasets with multiple waves of data.

2.2.2. Study sample

One of the main aims of the study, and the unique contribution from Bt30, is the ability to compare prospective and retrospective measures of ACEs. Since attrition increases over time, the final analytic sample was dependent on the number of participants who provided retrospective accounts of ACEs at age 22 out of the 1,636 participants who responded in that wave. Analytic samples were drawn from the larger Bt30 cohort based on the availability of data for exposure and outcome variables. For each objective, the available sample with sufficient data on the relevant variables comprises the analytic sample. Descriptions of the samples' characteristics are included with each piece of analysis in Chapters 3-5 and summarized in Table 1.

Table 3: Analytic samples in the study

Study objective	Analytic sample	Chapter
Develop prospective and retrospective profiles of ACEs for the Bt30 cohort and explore the consistency across the timing and source of these reports of ACEs.	• 1,595 participants with both prospective and retrospective accounts of ACEs	3
Explore the potential role of recent stressors in the relationship between ACEs and health and wellbeing outcomes.	• 1,592 participants with data on prospective and retrospective accounts of ACEs and both psychological distress and recent stressors at age 22	4
Examine the relationship between ACEs and a range of social and physical and mental health outcomes in the cohort.	• 1,592 participants with data on prospective and retrospective accounts of ACEs and both psychological distress and recent stressors at age 22 • 1,436 participants with data on prospective and retrospective accounts of ACEs and social, physical and mental health outcome data at age 28	4 & 5
Explore the prevalence and patterning of ACEs to determine their co-occurrence or clustering.	• 1,436 participants with data on prospective and retrospective accounts of ACEs and social, physical and mental health outcome data at age 28	5
Identify sex differences in exposure to ACEs and related associations with poor outcomes.	• 1,436 participants with data on prospective and retrospective accounts of ACEs and social, physical and mental health outcome data at age 28	

2.2.3. Study measures

The measures used in this study are described below, categorised by exposures, outcomes and covariates.

Exposures

The key exposure in the study is adversity in childhood measured as ACEs. The original 10 item ACE questionnaire from the ACE study was adapted into a 13-item questionnaire (Figure 13). Minor language changes were made for ease of understanding in a local context.

ACEs are defined as: physical abuse, sexual abuse, emotional abuse or neglect, and household dysfunction in the form of experience of divorce or parental separation, child separation, exposure to intimate partner violence, exposure to community violence, experience of living with a chronically ill individual, experience of living with an individual with substance abuse problems, legal problems in the households including incarceration, death in the household, parental death, and chronic household unemployment. Emotional abuse and neglect were collapsed into one ACE called emotional abuse and/or neglect. The five additional ACEs to the 10-item ACE index are chronic unemployment, community violence, child separation, parent death and household death.

The decision on which ACEs to include in an expanded set of ACEs was based on contextual relevance and availability in the data. ACEs are considered potentially traumatic experiences or characteristics of a child's environment that undermines their safety, stability, relationships and bonding. The prospective data available in Bt30 were reviewed to include variables that fit this definition of ACEs. Given the pervasiveness of violence and poverty in South Africa, a decision was made to include both violence inside and outside the home, as well as an indicator of poverty. Chronic unemployment is assessed using the question 'Was one or more of your parents/caregivers mostly unemployed during your childhood because they could not get a job?'. I use chronic household unemployment as a proxy for poverty, given that research has consistently shown unemployment is a strong predictor of poverty [113, 114]. While poverty can be more pervasive and persistent than other ACEs, preceding many of them, and reinforcing the negative outcomes of others, the rationale for including poverty (proxied by chronic unemployment) as an ACE rather than a contextualizing factor is based on a two reasons. Firstly, despite poverty being a precipitating factor for other ACEs such as food insecurity and physical neglect, poverty itself is a strong predictor of poor health outcomes in later life in ways similar to other ACEs [115]. And secondly, the mechanism through which poverty operates on later life outcomes mirrors that of other ACEs; poverty is a stressful experience for children leading to psychosocial and biological maladaptations that present as poor health and wellbeing [116].

Literature also supports the inclusion of child separation, parental and household death and community violence as ACEs. For example, the death of a parent in childhood has been linked to poor self-rated health in adult for women, explained by stress associated with the loss, potential

lack of nurturing care or bonding, and declines in household income [117]. Similarly, the death of a non-parent family member can have equally traumatic and broader consequences [118, 119]. Changes in family composition – or at least household composition, can also result from residential mobility for a number of reasons. Bt30, along with other studies, documents children's mobility and highlights the challenges that a child separation can pose [111]. The effects of community violence on children have long been documented and are found in South African literature [120], including in Bt30 [121], and I hypothesize that this impact would carry into adulthood.

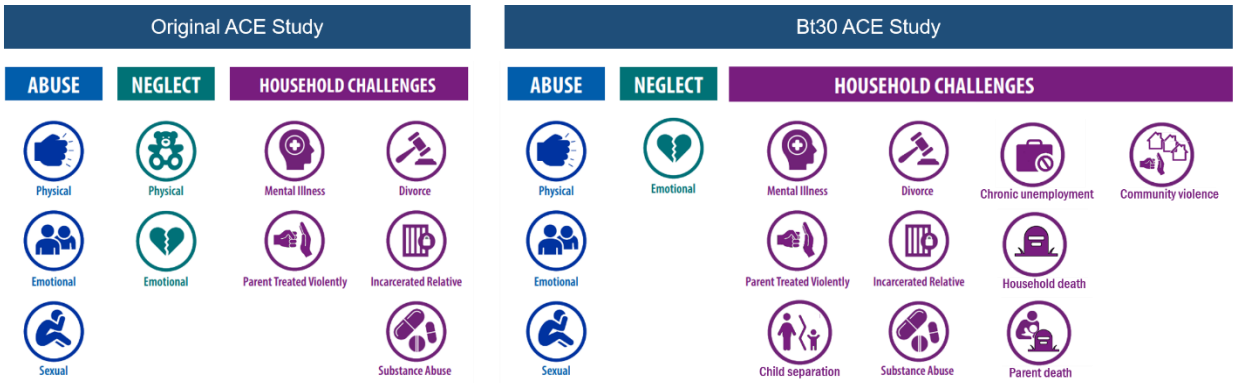


Figure 13: Expanded ACEs included in the study compared to the original ACE Study

A prospective and a retrospective profile of ACEs was compiled for each participant (Figure 14). For the prospective profile, data on the ACEs were collected from the antenatal period to age 18, initially from caregivers and then from the Bt30 participants themselves. These prospective profiles can be separated into a caregiver report covering the ages 0, 5, 7 and 11; and an adolescent report covering ages 11, 15 and 18. Retrospective profiles were compiled through self-reported exposure to ACEs at the 22-year data wave in young adulthood. Altogether, the data making up ACE profiles were pooled from 110 questionnaire sources from the Bt30 study.

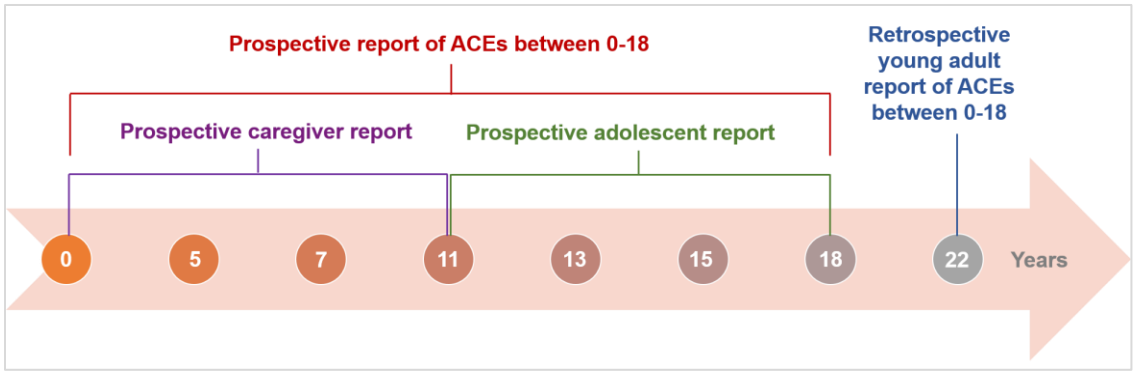


Figure 14: Composition of prospective and retrospective profiles of ACEs

Single ACEs

For both prospective and retrospective profiles, each ACE is recorded as a single variable. At each of the time points where ACEs were collected, a set of binary indicators was derived to represent a single ACE variable, for example 'physical abuse at age 13' is coded '1' for a positive response and '0' for a negative response. The single ACEs were then aggregated to compose the prospective report; if a participant ever gave a positive response for exposure to an ACE, this was recorded as '1'. Sub-sets of these profiles were also created for comparison within prospective profiles to create the caregiver report in early childhood and the adolescent report. The retrospective reports were much simpler; these variables were collected at one point (22-years) with yes/no questions coded as 0-1. The ACEs retrospective questionnaire and extracts from prospective questionnaires are included as Appendix 5.

Cumulative ACEs

To obtain a cumulative measure of ACEs, the binary retrospective and prospective profiles were summed for a total retrospective ACE score and a total prospective ACE score, ranging from 0-13 for prospective ACEs and 0-11 for retrospective ACEs. These continuous measures were then divided into two five-level categorical variables as is conventional in the literature. A retrospective categorical variable with levels 0 = no ACEs, 1 = one ACE, 2 = two ACEs, 3 = three ACEs, 4+ = four or more ACEs; and a prospective categorical variable with the same levels.

Clustered ACEs

A clustered ACE variable was obtained using latent class analysis. The process resulted in two categorical ACE variables, one prospective and one retrospective, with four levels each. Full details on the method and clustering of these variables are detailed in Chapter 5.

Recent stressors

An assessment of recent stressors in the past 6 months was made at the 22-year wave. This assessment probes 9 negative life events including violence in the households, household illness, disability and more. The influence of recent stressors on ACEs and on outcomes was examined. Similar to the ACEs profiles, recent stressors were transformed into a continuous measure by summing individual stressors.

Outcomes

A range of outcomes were assessed to examine the wide-reaching effects of ACEs on health and wellbeing. These outcomes are listed below (Table 4) and their treatment described in detail in Chapters 4 and 5. The questionnaires assessing outcomes are included in Appendix 2.

Table 4: Physical and mental health and social outcomes assessed in the study

Physical health	Mental health	Social
HIV infection	Psychological distress	Education attainment
	Depression	Employment
	Anxiety	Welfare receipt
	Somatization	Social isolation
	Social dysfunction	Substance abuse
		Criminality

Covariates

Covariates were selected for inclusion in various pieces of analyses based on their relevance in the relationship between ACEs and specific outcomes. The list of covariates include sex, SES at birth, SES at age 12, SES at age 22, maternal education, paternal education, maternal age at birth, and recent stressors. Sex was removed as a covariate in sex-disaggregated analyses.

2.2.4. Data management

The Bt30 data is stored securely on the REDCap data management system with no personal identifiers linked to the data. Requests for relevant raw data are made to the Executive Committee of the study and a data agreement guiding its use is approved by the Committee. The raw data is transformed by the researcher and resulting analytic datasets are lodged with the Committee after use. The researcher therefore has full access to all the data used in the study and any codebooks associated with the data.

2.2.5. Statistical analysis

Analyses in the study were conducted using STATA statistical software version 13.0 and later version 15.0. Mplus version 8 was used to perform latent class analysis. Separate analysis approaches for each objective are detailed in Table 5; detailed information on the analyses are included in Chapters 3, 4 and 5 where each objective is investigated.

Table 5: Statistical analysis approaches used in the study

Study objective	Statistical analysis	Chapter
Develop prospective and retrospective profiles of ACEs for the Bt30 cohort and explore the consistency across the timing and source of these reports of ACEs.	• Descriptive statistics and frequencies to create ACEs profiles • Generating Cohen's kappa statistic to assess interrater reliability – levels of agreement between prospective and retrospective reports • Generating concordance rates measuring strength and direction of agreement of prospective and retrospective reports	3
Explore the prevalence and patterning of ACEs to determine their co-occurrence or clustering.	• Descriptive statistics to explore frequencies • Latent class analysis which groups individuals based on patterns of co-occurrence of ACE exposures	5
Examine the relationship between ACEs and a range of social and physical and mental health outcomes in the cohort.	• Chi-square tests to examine the co-occurrence between ACEs and mental health	4
	• Logistic regression analysis to examine the influence of ACEs on physical and mental health and social outcomes	4 & 5
Explore the potential role of recent stressors in the relationship between ACEs and health and wellbeing outcomes.	• Factorial analysis to test the interactions between recent stressors and ACEs on mental health outcomes • Pearson correlations and linear regression analysis to test for mediation or moderation effects on recent stressors on mental health outcomes	4
Identify sex differences in exposure to ACEs and related associations with poor outcomes.	• Logistic regression disaggregated by sex to examine influences of ACEs on physical and mental health and social outcomes	

2.2.6. Ethical considerations

ACEs, by nature, are sensitive topics, particularly within child and adolescent populations where huge emotional demands are placed on the participant. Although the sensitivity of a topic is not a measure of either its social or theoretical significance; research on sensitive topics seems to frequently tap into society's most pressing issues and challenges [122]. Researchers have argued that it is important to ask about histories of child maltreatment to ensure that important predictors of later life outcomes are not overlooked [123]. The plethora of research showing associations

between adversity and social and health problems in later life illustrate that research not asking participants about childhood trauma and abuse overlooks significant risk factors for a long list of diseases, disorders and risk behaviours [124].

Sensitive topics also raise methodological and technical problems. For one, confidentiality and anonymity is of utmost importance and Bt30 has methodical guidelines on how these issues are approached in any contact with participants. Each participant is allocated an identification number, not linked to personal information, which is used on all questionnaires. All participants provided written informed consent at each individual data collection wave. Written consent was obtained by parents or guardians when children were minors, with verbal assent from children. Participants were able to provide written consent from age 16 to 28 for each individual data collection wave. Follow up intervention of care for participants is done in two stages. In the first, fieldworkers administering the questionnaire or interview are trained to indicate in their study notes if a participant appeared to be under psychological distress. These notes are then reviewed at the end of each day. In the second stage, a built-in algorithm is processed during data capture on items probing for serious issues or distress such as 'suicide ideation in the past month'. The resulting calculation will produce a positive for a 'mental health referral needed' variable. Participants showing signs of distress in either stage are put in contact with social and health services linked to the study.

Ethical clearance for each wave of data collection for the Bt30 cohort study is obtained from the Human Research and Ethics Committee (HREC) of the University of the Witwatersrand (Wits). The ethical clearance numbers for the two waves of data collection used in the bigger Bt30 study are M111182 for the 22-year wave and M010556 for the 28-year wave. Ethical approval for this sub-study was granted by Wits HREC with the ethics clearance number M140726 (Appendix 3).

2.2.7. Candidate's role in the study

PhD candidates working within the larger DPHRU unit, which oversees the Bt30 study, are expected to be actively involved in the study activities as well as carry additional responsibilities for post-graduate students. The candidate led this study, with activities feeding into the larger Bt30 study.

My role is reflected under the following sub-headings:

Conceptualization of the study

Given the vast amount of data available, initial work was done to review the data, particularly data that has not been published, and in line with my background and research interests, identify an area that I could take ownership of. I had been working in adversity and early childhood and had come across the literature on ACEs. Preliminary work began on delving into the data in Bt30 to understand if it was possible to put together data that could build an ACE profiles for the study population. Once it was determined that there was potential to do so, I sifted throughout the more than 20 waves of data to identify which variables could be used to create the ACE profiles. This was then added to an Excel spreadsheet which listed each variable, by year or wave, and by respondent.

Building of analysis plans

The analysis plans were built around the research questions I wanted to tackle. The research questions were drawn from the literature reviewed and in an iterative process I built an analysis plan for each research question based on good practice found in the literature.

Primarily, it was important for myself and my supervisors to maximize the use of the data by contributing an original piece of work to the field. One unique aspect was that we had a broad range of prospective data on adversity across childhood, and an opportunity in the upcoming 22-year adult data collection wave to generate a retrospective profile of the same ACEs.

The outline of the doctoral study then centred around three areas (which were later crafted into research questions and objectives):

- What did ACEs in South Africa look like, given the high levels of violence and adversity already plaguing the population?
- How different would prospective reports of ACEs and retrospective reports of ACEs look?
- Could ACEs in a South African sample be linked to poorer outcomes in similar ways to high-income countries?

The analysis plans stemmed from these critical questions.

Literature reviews

I reviewed the general ACEs literature, with mini-reviews tailored for each publication based on that publication's focus. Issues around measurement, ways to analyse ACEs and conceptualizations of adversity and trauma were also researched. The review of the literature was an ongoing task as the peak of publications in the field coincided with the period of this doctoral work. As new findings, methodologies, critiques and questions arose from the literature, these were built into the analysis plans, when deemed necessary and useful.

Development of retrospective ACE questionnaire

As the new 22-year data collection wave loomed, I worked with the larger study team to prepare for the data collection. My role was to develop the retrospective ACEs questionnaire, modelled on the CDC-Kaiser ACE index but adapted in language and content to suit the South African context, while maintaining comparability. Meetings with the team were held to take decisions on how the questionnaire would be administered, where in the pack of modules it would be located and how the data should be captured.

Data management, including lodging requests for data, pulling and cleaning data, quality check on data, compiling and lodging analytic datasets back to the study

Once the data had been collected, I was responsible for the data generated from the retrospective ACEs questionnaire, including the cleaning and quality control on the hard copy data at the Bt30 offices. Cleaning of the data also extended to the prospective data and some of the outcome data, this occurred during weeks of in-person visits to the Bt30 offices.

Analytic datasets for each publication were crafted, with codebooks, and lodged back to the study committee.

All data analysis for the study

I conducted all data analysis in each of the papers, and any new analysis in the thesis. In some cases, this required addition training on statistical packages and methods I had not previously used. Data interpretation was also my responsibility.

Lead the writing of manuscripts

I led each of the publications in this doctoral study. This included putting together the first draft of the paper which comprised a literature review, methods section, the analysis, interpretation of

the results, a draft of the discussion and conclusion. Along with my supervisors, collaborators that could add value to the work and who I had developed a working relationship, were invited to co-author the papers. For each paper, the conventional method of publication writing was followed. The lead author, in this case myself, would develop the first draft and share with the proposed authors. On average, for each paper, we would meet 4 to 6 times to discuss the paper and I would carry out any subsequent analysis, writing or integrating of feedback. I was also responsible for submitting publications, identifying relevant journals, handling the submission process, revisions, reviewer responses and any securing funding for any publication charges.

Overall, I had good guidance from my supervisors but a wide berth to direct and conduct the research independently.

PART 2: EMPIRICAL CHAPTERS

CHAPTER 3: CONSISTENCY BETWEEN PROSPECTIVE & RETROSPECTIVE ACES

An analysis of retrospective and repeat prospective reports of adverse childhood experiences from the South African Birth to Thirty cohort

3.1. Introduction

Made familiar by the CDC and Kaiser Permanente's ACE Study [19], retrospective adult reports of childhood experiences of abuse, neglect and household dysfunction have been linked to a range of adverse social and health outcomes in later life [3, 4, 35, 45, 58, 63, 74, 77, 125-136], studied predominantly in high-income countries. Growing evidence from around the world suggests that ACEs tend to cluster together [15, 129, 134, 137]; for example, that childhood sexual abuse often occurs in the presence of other ACEs [19], and that the risk for adverse outcomes increases in a strong and graded manner as the number of ACEs increase [15, 138]. The ACE score, the total number of ACEs to which an individual reports having been exposed before the age of 18, enables one to examine the cumulative impacts of ACEs on later life outcomes.

In recent years a number of South African studies have assessed the impact of childhood adversity on health and wellbeing [73, 139], including one longitudinal prospective study of cumulative adverse childhood experiences [60]. The associations between exposure to ACEs and negative outcomes follows a pattern similar to other countries. Since the inception of its democracy more than 20 years ago, South Africa has transitioned rapidly from a setting characterized by poverty, underdeveloped infrastructure and limited resources. Yet high levels of inequality and unemployment, along with a generalized HIV epidemic adding another dimension to the experience of adversity [58, 73, 133], present conditions where exposure to multiple and concurrent ACEs is prevalent around the country [60].

The few long-term studies that have been conducted LMICs tend to examine associations between retrospectively reported single childhood adversities and outcomes. In countries that participated in the Global School-based Student Health survey in 2003/2004, specifically Namibia, Swaziland, Uganda, Zambia and Zimbabwe, associations were found between 12-

month retrospective reports of exposure to physical and sexual violence with mental health, suicide ideation, substance use, multiple sex partners and a history of sexually transmitted infection among 13-15-year-olds [140]. Other studies have linked reports of early adversity to personality and current major depressive disorders in Togo [141]; a range of sexual risk behaviours, alcohol and drug use, and intimate partner violence in South Africa, Tanzania and Zimbabwe [16]; and elevated likelihood of adult substance use disorders in Nigeria [13]. In South Africa, exposures to adverse experiences in early life have been associated with a number of poor adolescent and adult outcomes, including HIV risk [58], methamphetamine use [130], psychological distress [142], the perpetration of both non-partner and partner rape [139], and increased risk of psychiatric disorder [134].

There are some prospective studies linking exposure to ACEs to social and health outcomes such as psychological, behavioural, and academic problems in adolescence [143]; HIV risk behaviour at age 14 [144]; obesity and type 2 diabetes [20]; mental health [37]; premature mortality [145]; chronic pain [146]; and age-related disease [147]. Most often this prospective data comes in the form of school records, which are frequently incomplete and focus on a small set of ACE variables, or historical court and child protection service records which are typically available when cases are extreme [32, 44]. There are far fewer prospective studies of ACEs than it may appear since multiple publications using prospective data are often from a single study, as with the 1958 British birth cohort [20, 144-146, 148]. We could find no prospective or quasi-prospective studies on ACEs and later life outcomes located in LMICs. In their 2012 meta-analysis, Varese and colleagues [149] found eight prospective studies linking childhood adversities to psychosis from the Netherlands (3), the United Kingdom (2), Finland (1), Germany (1) and Australia (1).

The reliance on retrospective recall raises questions about the extent to which reports are valid (accurate), reliable (consistent) and free from bias relevant to the hypothesis at hand. Additional methodological challenges include the possibility of confounding factors accounting for both early adverse experiences and later outcomes examined. Validity of reports depends on a number of factors, such as memory, cognitive function at the time the event occurred, and subsequent life experiences that may change a person's outlook [150-152]. For instance, people who experience

adverse health and social outcomes in later life may be more likely to recall and/or report having experienced adverse experiences during childhood [74].

Inconsistencies affecting the reliability of retrospective responses can occur for a number of reasons. Apart from deficits in memory due to a lapse in time, repression of memories may result from stressful events experienced [75]. Recall is also altered by subsequent events, whether experiences at the time or later were discussed with others or overheard, and if help or treatment was sought. Rothman and Greenland [76] propose that some of these factors might lead to misclassification of exposed individuals as unexposed, leading to a downward bias of the association between ACEs and various outcomes, a finding also reported by others [77, 78]. In contrast, the dilemma of false-positives or over-reporting is virtually impossible to establish [153].

Some research has been conducted to ascertain the reliability and validity of retrospective ACE reports. In terms of validity, it has been found that even where childhood sexual abuse has been documented, retrospective recall, even in young adulthood, can be low [154, 155]. The validity of retrospective reports is difficult to confirm [84], but establishing reliability over time of retrospectively reported ACEs is a more manageable task. This has been done by examining the reliability of reports using a test-retest paradigm where the same respondents are questioned on two occasions [79, 81, 82, 156-164]; assessing reliability using two separate measures of adversity [165, 166]; and looking at the concordance or corroboration between two different report sources [167]. A further limitation is that most studies examine the reliability of reports on only one or two adverse experiences. Fewer studies assess reliability over time of a range of childhood experiences [162].

Studies comparing the prevalence of reported ACEs using historical prospective data such as court records and retrospective reports have found substantial under-reporting in the former [168]. Few direct comparisons of prospective and retrospective data on childhood adversities and their consequences in a single sample have been conducted. In four studies comparing documented records of child sexual and physical abuse and neglect [169-171] and child hospitalization [172], significant associations between childhood adversity and negative outcomes were found when retrospective self-reports, but not prospective documented records, were analysed.

The aim of this analysis is to use the opportunity afforded by the Bt30 data over 22 years to explore levels of agreement and concordance in prospective reporting of ACEs from children and caregivers at different time points with retrospective reports in young adulthood.

3.2. Methods

3.2.1 Study design and participants

Ethics clearance was obtained from the Witwatersrand University Committee for Research on Human Subjects (M140726). The Bt30 study began as Birth to Ten, a birth cohort study in Soweto-Johannesburg with the objective of tracking a group of urban children in South Africa at a time of very significant political, social, demographic and health transitions, born as they were just weeks after Nelson Mandela's release from prison. Extended to Bt20+ and now Bt30, the sample consists of all singleton children born to mothers who were residents of Soweto-Johannesburg in the 7-week enrolment window and who remained in the area up until the child reached 6 months of age. The Bt30 cohort is now 32 years old, and includes the third generation of children born to the original cohort. A detailed description of the study, its birth cohort and participants is published elsewhere [102]. The sample analysed in this paper comprises 1,595 participants who were surveyed at the 22-year data collection point, when they provided retrospective data on ACEs, and prospectively throughout the cohort study. Prospective reports of ACEs from parents and children were recorded at six time points across childhood and adolescence. Written informed consent was obtained from parents and guardians of all children included in the study. Informed assent, and later consent at the appropriate age, was obtained from children for their participation in the cohort. Since a child may not be raised by a biological parent for a number of reasons, the term caregiver will be used to refer to the primary caregiver of the child.

3.2.2. Measures

Adverse childhood experiences

Bt30 collected data on a wide range of topics including variables related to ACEs, initially from caregivers and subsequently from the Bt30 respondents themselves. These variables include exposure to crime and violence, experiences of emotional, sexual and physical violence, poverty, family dysfunction and more. ACEs are defined in this study in the same way as in the original ACE study: as physical abuse, sexual abuse, emotional abuse, physical or emotional neglect, and

household dysfunction in the form of experience of divorce or parental separation, exposure to intimate partner violence (IPV), experience of living with a chronically ill or disabled individual or an individual with substance abuse problems, parental death, household legal trouble, and chronic household unemployment. Table 6 shows the child's age at which these variables were assessed. At child age five, seven and 11 years the caregiver was asked a number of ACE questions relating to her child. Between 11 and 18 years of age, the child responded to a number of ACE questions. The caregiver and adolescent reports are regarded as prospective reports of ACEs. At the 22-year data collection wave, a retrospective report on adverse experiences during the first 18 years of life was obtained from respondents through a set of questions modelled on the CDC-Kaiser Permanente ACE questionnaire. Appendix 1 lists the ACEs-related survey questions used throughout the study.

Table 6: Child ages at time of caregiver, adolescent & young adult ACE reports

ACE variable	Caregiver reports			Adolescent reports			Young adult report
	5	7	11	11	15	18	23
Physical abuse	●	●		●	●	●	●
Sexual abuse	●	●		●	●	●	●
Emotional abuse	●	●			●	●	●
Divorce/separation	●	●	●	●	●		●
Exposure to IPV	●	●	●		●	●	●
Household substance abuse	●	●	●				●
Serious illness or disability in the household	●	●	●	●			●
Household legal trouble	●	●	●		●	●	●
Chronic unemployment	●	●	●	●			●
Parental death		●		●	●	●	●
Death in the family/household	●	●	●	●		●	
Separation from parents	●	●	●	●			
Exposure to violence and crime	●	●	●		●	●	●

In sum, three accounts of ACEs are examined and compared: caregiver reports about the child's environment and experiences at the time; young adolescent reports about their own environment and experiences at the time, and young adult retrospective reports about their environment and

experiences in the first 18 years of life. Prospective caregiver reports and prospective adolescent reports are individually compared to retrospective young adult reports. Combining the caregiver and adolescent self-reports, a prospective report across childhood is also compared to young adult retrospective reports about the same period.

3.2.3. Analysis

Descriptive statistics were used to summarize caregiver and adolescent reports of exposure to ACEs at different time points as well as the prevalence of reported ACEs. Cohen's kappa was calculated to compare item agreements between prospective caregiver and adolescent reports of ACEs with retrospective young adult reports of ACEs. Kappa examines agreement adjusting for chance and has been used in several other studies of the reliability of reports of childhood experiences [79, 85, 162, 173]. We followed Landis & Koch's [174] classification on the strength of agreement. The percentage of item agreement between both time points, or concordance rate, was also calculated as suggested by de Mast [175] to overcome Kappa values that may be affected by the number of ‘yes’ responses that are due to rare events or very common events resulting in artificially low kappa values.

3.3. Results

Figure 15 shows the prevalence of reported experience of ACEs by caregivers about children's lives up to age 11 years. Blank spaces indicate that questions on this ACE were not asked at a particular age. A combined caregiver report is calculated as the prevalence of ever reporting an ACE in the 6-year period between 5 and 11 years. Divorce/separation, household substance abuse, serious illness or disability in the household, death in the household and exposure to violence and crime were reported at roughly the same rates when children were 5, 7 and 11 years old. Chronic unemployment was the most frequently reported ACE at each time point, increasing to 81.9% when the caregiver reports at child age 11 years. Combined time points show that about 82% of children younger than 11 were living in a household that reported chronic unemployment at least once.

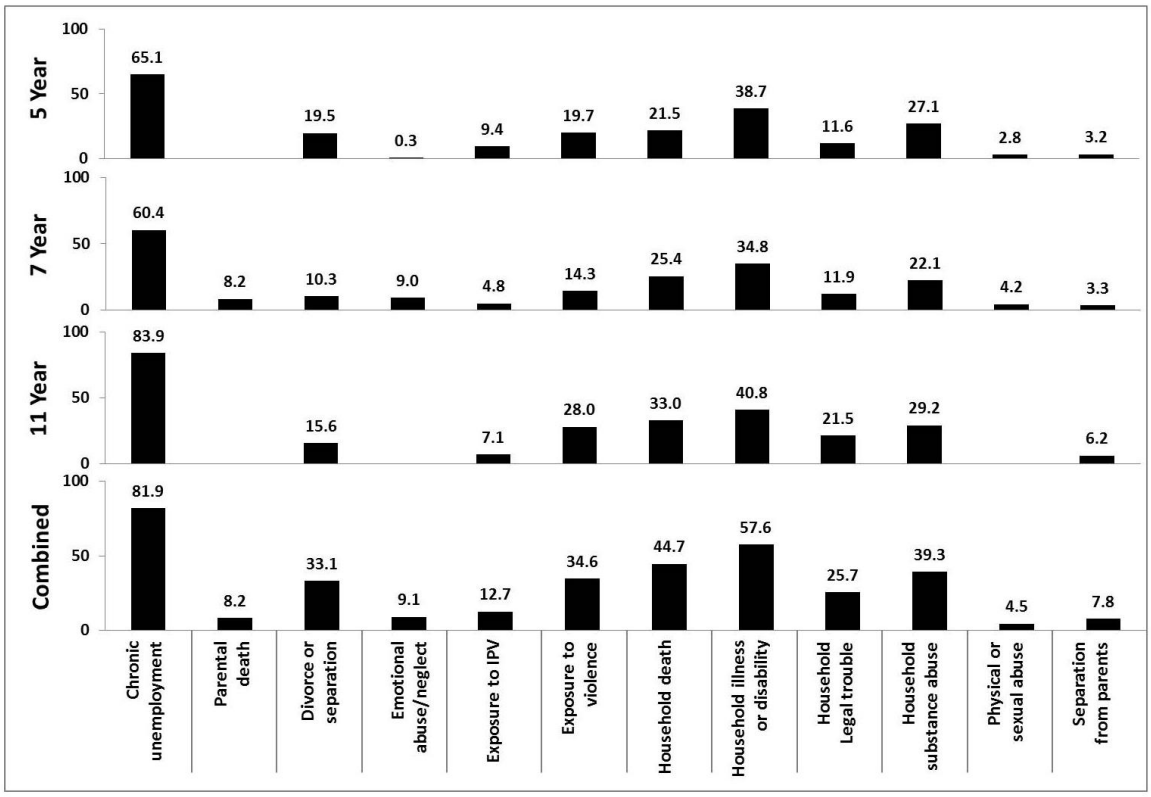


Figure 15: Prevalence (%) of ACEs at various child ages reported by caregiver in the first 11 years

Figure 16 looks at the average prevalence of ACEs reported by adolescents prospectively between the ages of 11 and 18. During their teenage years, young people are more likely to report the death of a parent, as well as increased exposures to violence, including sexual and physical abuse. Reports of physical abuse increase from 19.0% at 11 years to 44.4% at 15 years, decreasing to 22.1% at 18 years. Reports of sexual abuse by adolescents quadrupled from 9.3% at 15 years to 40.6% at 18 years. The combined adolescent report shows that 48.6% of adolescents report exposure to physical abuse at least once during the 11-18 year period.

Young adult retrospective reports of ACEs occurring before they turned 18 are shown in Figure ***17***. Divorce/separation and chronic unemployment in the household are the most frequently reported ACEs at 44.9% and 43.5%, respectively. Retrospectively reported physical abuse is much lower – at 7.8% – compared to combined adolescent reporting of physical abuse at 48.6%.

Figure 18 shows the prevalence of reported ACEs by source – caregiver, adolescent or young adult – and time point – prospective or retrospective. Across sources there is consistency in the reporting of exposure to violence and family instability, namely divorce/separation and child separation from parents. Adolescent prospective reports of physical and sexual abuse, exposure

to IPV and more general exposure to violence are much more prominent than prospective caregiver reports or retrospective young adult reports. Caregivers report a substantial social and material burden on the household in the early years of the child's life, with high levels of chronic unemployment, household death, illness/disability and substance abuse.

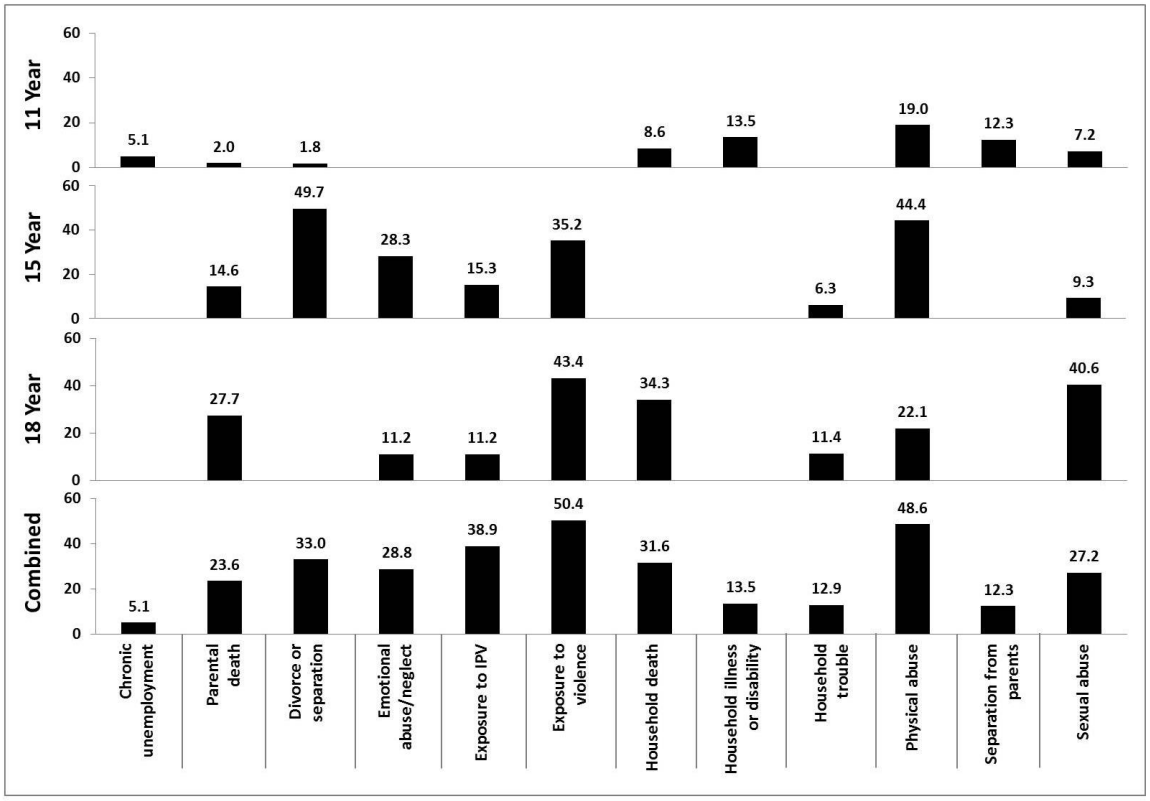


Figure 16: Prevalence (%) of ACEs reported by adolescents between 11 and 18 years of age

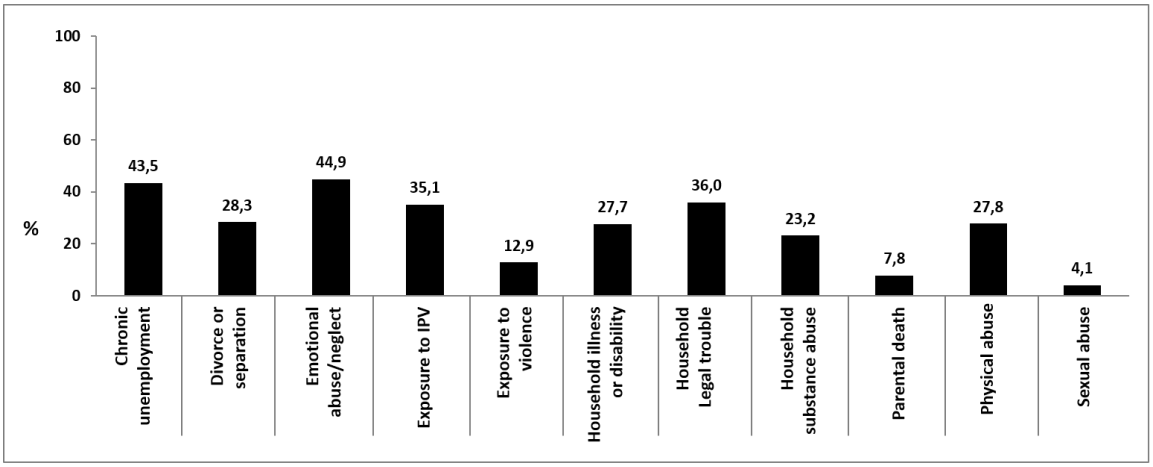


Figure 17: Prevalence (%) of ACEs retrospectively reported by young adults at age 22 years

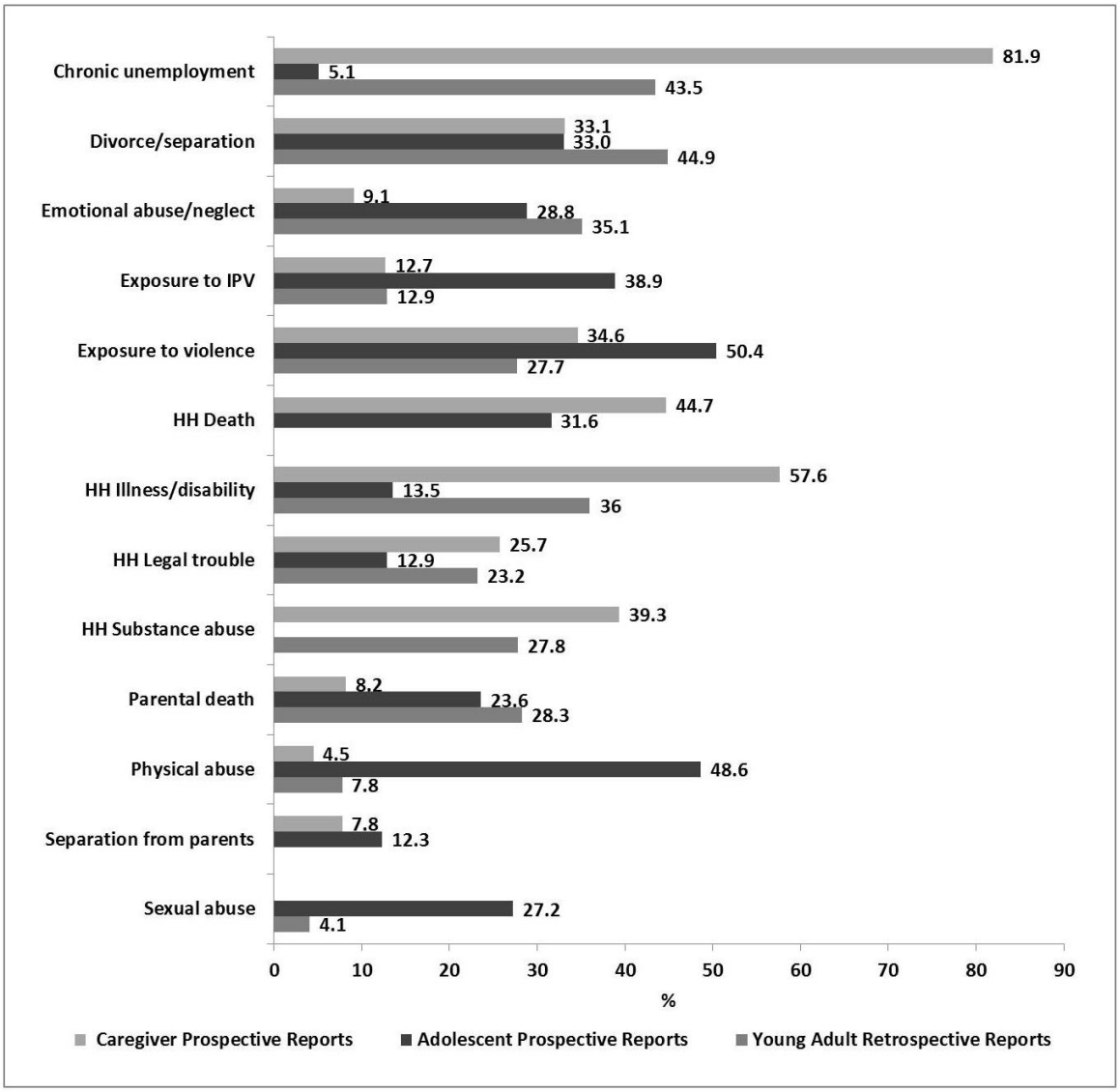


Figure 18: Prevalence (%) of ACEs by source and time point

Comparing young adult retrospective reports to caregiver and adolescent prospective reports about adverse experiences in childhood

Comparisons are made to determine the levels of agreement between prospective caregiver reports about childhood and prospective adolescent self-reports with retrospective reports by young adults. Levels of agreement between combined prospective caregiver and adolescent reports of ACEs compared to retrospective young adult reports of ACEs were also examined using Cohen's kappa (Table 7). The concordance rates reflect total agreement on an ACE whether reported present or absent at both time points or by both sources.

Table 7: Level of agreement between ratings for prospective caregiver and prospective adolescent reports compared to retrospective young adult reports of ACEs

ACE Variable	Cell frequencies				k	Conc. Rate
	N1/N2	N1/Y2	Y1/N2	Y1/Y2		(%)
Combined prospective caregiver and adolescent reporting (1) compared to retrospective young adult reporting (2)						
Physical abuse	683	36	772	86	.05**	48.8
Sexual abuse	941	34	517	29	.02	63.8
Emotional abuse/neglect	691	304	328	244	.12**	59.7
Divorce/separation	473	187	245	397	.34**	66.8
Parental death	1022	187	97	251	.52**	81.8
Exposure to IPV	733	90	624	112	.05*	54.2
Exposure to violence	373	93	753	337	.08**	45.6
HH Substance abuse	612	185	496	235	.09**	55.4
Chronic unemployment	141	60	726	604	.07**	48.7
HH Legal trouble	805	189	394	175	.13**	62.7
HH Illness & disability	370	191	618	346	.02	47.0
HH Death	724	0	471	624	.51**	74.1
Caregiver reporting (1) compared to retrospective young adult reporting (2)						
Physical abuse	1116	94	63	7	.02	87.7
Sexual abuse	1127	49	59	3	.01	91.0
Emotional abuse/neglect	764	399	69	65	.07**	64.0
Divorce/separation	510	288	179	265	.22**	62.4
Parental death	872	294	40	78	.21**	74.0
Exposure to IPV	1118	132	158	53	.15**	80.2
Exposure to violence	671	242	396	161	.03	56.6
HH Substance abuse	642	197	435	212	.11**	57.5
Chronic unemployment	111	48	725	599	.05**	47.9
HH Legal trouble	835	221	301	127	.09**	64.8
HH Illness & disability	367	190	590	332	.02	47.3
HH Death	509	244	443	229	.02	51.8
Adolescent reporting (1) compared to retrospective young adult reporting (2)						
Physical abuse	709	38	736	82	.05**	50.5
Sexual abuse	968	35	475	28	.01	66.1
Emotional abuse/neglect	724	340	271	196	.11**	60.1
Divorce/separation	527	288	104	237	.31**	66.1
Parental death	1011	179	75	214	.52**	82.8
Exposure to IPV	807	113	532	87	.02	58.1
Exposure to violence	564	150	551	271	.02*	54.4
Chronic unemployment	557	396	23	27	.03	58.2
HH Legal trouble	963	260	123	69	.11**	73.0
HH Illness & disability	584	279	79	55	.05*	64.1
HH Death	1148	0	47	624	.94**	97.4

N1/N2 = *No* ACE reported by both; N1/Y2 = *No* reported by 1, *Yes* reported by 2; *$p<.05$ **$p<.0001$
Y1/N2 = *Yes* reported by 1; *No* reported by 2; Y1/Y2 = *Yes* reported by both
Conc. rate = concordance rate (percentage of participants with Y1/Y2 and N1/N2)

Across both combined caregiver and adolescent prospective reporting and separated caregiver and adolescent prospective reporting compared to retrospective young adult reporting there is significant agreement at moderate levels on parental death and household death (ranging from k=.51 p<.0001 to near perfect agreement at k=.94, p<.0001). There are fair levels of agreement for divorce/separation in each of the three comparisons, ranging from k=.22 to .34, p<.0001. Significant but slight levels of agreement are found for other ACEs across the comparisons.

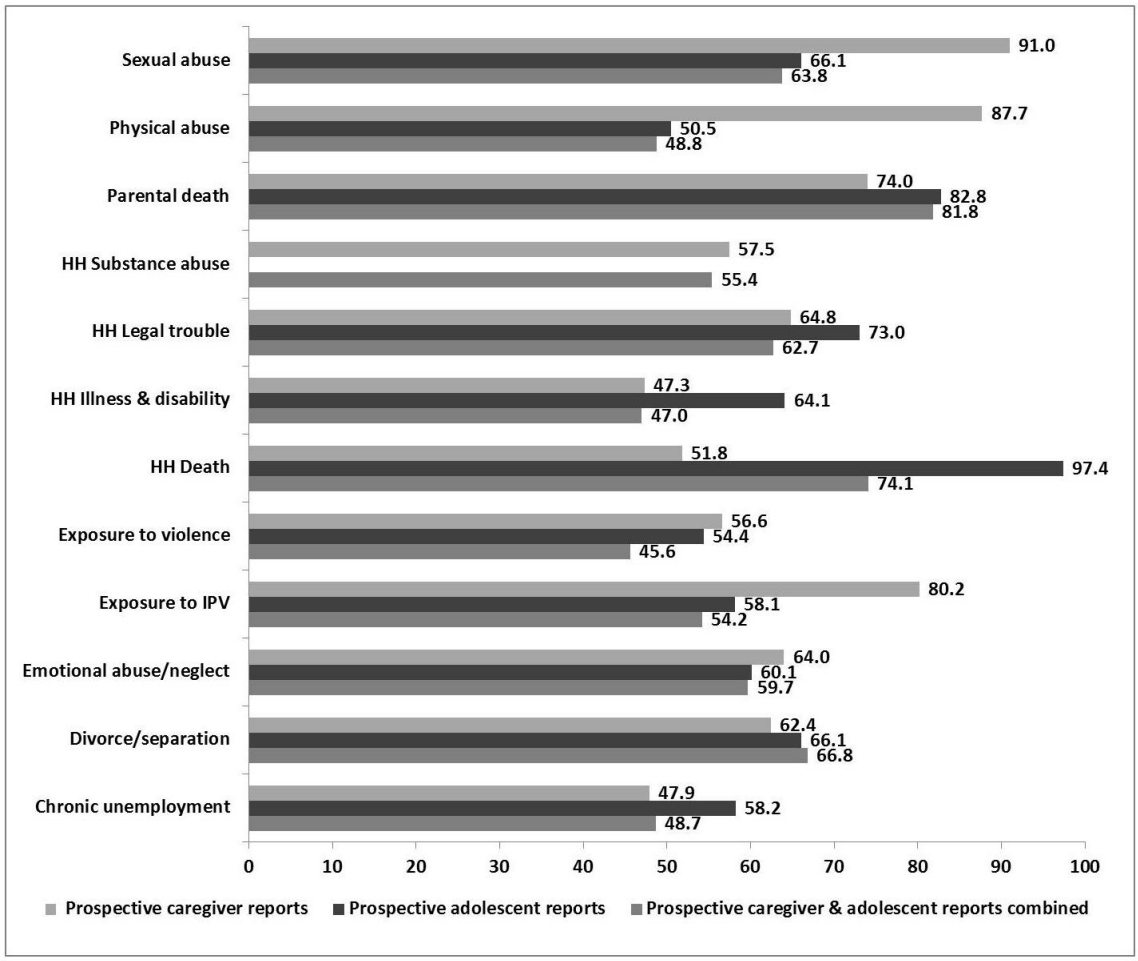


Figure 19: Concordance rates (%) for each ACE when prospective caregiver and prospective adolescent reports are compared to retrospective young adult reports, separately and combined

Figure 19 illustrates the concordance rates by ACE when comparisons between accounts are seen side by side. For ACEs such as parental death, household substance abuse, household legal trouble, exposure to violence, emotional abuse/neglect, chronic unemployment, and divorce/separation the concordance between the three reports remains relatively consistent. The highest concordance rate (97.4%) is found between prospective adolescent reports and retrospective young adult reports on household death. High concordance is also seen between

prospective caregiver reports and retrospective young adult reports on sexual and physical abuse and exposure to IPV (91.0%, 87.7% and 80.2%, respectively).

To understand how respondent source may play a role in reporting of ACEs, kappa values and concordance rates were calculated for ACEs that were reported on at the same time point for both caregiver and adolescent (at child age 11). Table 8 shows the levels of agreement for caregiver reported ACEs at age 11 and adolescent reported ACEs at year 11. Despite very low kappa values, concordance rates for reported divorce/separation and child separation are high at 83.2% and 85.1%, respectively, with both the caregiver and the adolescent reporting low levels of divorce/separation and prolonged child separation. In comparison, concordance on chronic unemployment in the household is low at 18.7%. About 4.8% of adolescents report chronic unemployment in the household compared to 80.1% of caregivers at the same time.

Table 8: Level of agreement between ratings for prospective caregiver reports (1) compared to prospective adolescent reports (2) of ACEs age 11

ACE Variable	Cell frequencies				k	Conc. Rate
	N1/N2	N1/Y2	Y1/N2	Y1/Y2		(%)
Household illness/disability	549	79	370	63	.02	57.7
Divorce or separation	877	14	163	3	.00	83.2
Household unemployment	151	5	854	46	.01	18.7
Household death	639	58	334	28	.01	63.1
Child separation	888	116	47	9	.03	85.1

N1/N2 = *No* ACE reported by both; N1/Y2 = *No* reported by 1, *Yes* reported by 2
Y1/N2 = *Yes* reported by 1, *No* reported by 2; Y1/Y2 = *Yes* reported by both
Conc. rate = concordance rate (percentage of participants with Y/Y and N/N)

3.4. Discussion

The aim of this study was to explore the levels of agreement between three accounts of reporting on ACEs – prospective caregiver reports on the period between 5 and 11 years in a child's life, prospective adolescent reports on the period between 11 and 18 years and retrospective young adult reports of experiences before the age of 18 years. In summary, we found that there was little overall agreement between combined or separate prospective accounts and retrospective accounts of childhood experiences, with a few exceptions that are described below.

3.4.1. The prevalence of reported ACEs

Overall the prevalence of individual reported ACEs was fairly high, naturally increasing by age – older children were more likely to report any given ACE, with poverty reflected in the pervasiveness of unemployment at a rate of 81.9% at its highest, a finding echoed by an analysis of the prevalence of ACEs among children in a nationally representative US sample [176]. In addition to economic hardship, the authors report high rates of exposure to violence and divorce or separation, similar to the current study's findings. At a national level, 46% of children in the US [176] and 46.4% of participants in an English sample [177] report at least one ACE, compared to 92% in retrospective reporting and 98.9% in prospective reporting in this study. In other developing countries, similar high prevalence rates of reported ACEs are found. A retrospective study of young people in Russia estimated that 84.6% of respondents reported at least one ACE [178], and in a Brazilian birth cohort, 85% of adolescents reported at least a single ACE [59].

Depending on the type and measure of ACEs used, the timing of measurement, and source, studies assessing the consistency of reporting of ACEs over time have found divergent results [79, 81, 84, 179]. There are substantial differences in the prevalence of reported ACEs across the three accounts assessed in this study. There are fairly consistent rates of reported ACEs across the three time points within the prospective caregiver reports, with less consistency in the prevalence of ACEs reported over the adolescent period. The prevalence of ACEs in adolescent reports tends to increase substantially around the 15-year period, particularly reports of physical and sexual abuse, and then decrease after the 18-year period. The prevalence of retrospectively reported ACEs by young adults is similar to that of prospective caregiver reports, particularly with regard to ACEs in the home environment such as chronic illness/disability, substance abuse, legal trouble, divorce/separation, and chronic unemployment in the household, and even extending to their own experiences of physical and sexual abuse.

Adolescents prospectively report much higher rates of exposure to violence, physical and sexual abuse than are reported retrospectively or by caregivers. As they enter secondary school and their environment expands to include peers, the range of experiences open to adolescents is greater which may explain these increases. In the adolescent reporting period, non-consensual petting and/or oral sex, in addition to penetration, are explicitly included in the operational definition of

sexual abuse. As a developmental period, adolescence is also characterized by some level of egocentrism, perhaps making them acutely conscious of the events in their own lives and with a heightened perception of the severity of experiences. Research also suggests that memory is generally enhanced in adolescence and early adulthood [180], leaving adolescents less likely to forget negative experiences [181].

3.4.2. Levels of agreement across time

Overall, a combined prospective account of ACEs showed only slight levels of agreement with retrospective young adult reports. Seventy-five percent of kappa values fell within the slight agreement range, 8% had fair agreement, and 17% had moderate agreement. When comparing prospective caregiver reports to retrospective young adult reports, 83% of kappa values represented slight agreement and 17% fair agreement. Prospective adolescent reports, compared to retrospective young adult reports, yielded 73% slight agreement; 9% fair, moderate and near perfect agreement, respectively. In all comparisons, the highest levels of agreement were found on household death and parental death. Yancura and colleagues found similar results noting that specific events such as deaths in the family and parental separation tended to have higher kappa values than other experiences [162]. The lowest levels of agreement are found in comparisons between prospective caregiver reports of ACEs and retrospective young adult reports of ACEs. One possible reason for this is that caregiver prospective reporting covered early to middle childhood, ending when the child was 11 years of age; the years of adolescence following this period are likely to include a larger range of experiences and greater opportunity for ACEs to occur.

Concordance rates of the different ACEs across the three comparisons mirrored agreement levels with the exceptions of physical and sexual abuse and exposure to IPV in the comparison between prospective caregiver reports and retrospective young adult reports. This could be as a result of the differences in the prevalence of reported physical and sexual abuse and exposure to IPV that increase in adolescence but is not retrospectively reported on in young adulthood. Despite the low kappa values, these high levels of concordance could be due to low endorsement rates or the rarity of the event compared to other ACEs. The concordance rates for each ACE when prospective caregiver and prospective adolescent reports are compared to retrospective young adult reports, separately and combined, are fairly consistent. This suggests that the nature of the

ACE will influence how it is reported, over and above timing and source issues. Apart from a few individual ACEs – sexual abuse, physical abuse and exposure to IPV in the prospective caregiver report and illness/disability and household death in the prospective adolescent report – the prospective accounts, separately or combined, do not appear to be highly concordant with the retrospective young adult account. This finding might have been anticipated, given that a study examining retrospective reports of childhood abuse just three years apart – at 18 and 21 years old – found substantial unreliability between reports [182].

3.4.3. Levels of agreement across source

Comparing prospective caregiver reports over the first 11 years of a child's life to retrospective self-reports in young adulthood is precarious in that the period of adolescence is unaccounted for. What may appear to be over-reporting in retrospective reports may simply represent events experienced during the adolescent period. But caregiver reports on the experiences in the early years of a child's life are also useful in understanding the impact of the early environment on later life, regardless of later recall, when confounding factors can be controlled for. In the first 11 years of the child's life caregivers report a large burden of care at the household level with high levels of substance abuse, legal trouble, chronic unemployment, chronic illness and disability, and family death. Children and adolescents may not always be aware of the level of adversity or the subsequent strain put on caregivers. In this analysis there were overall low levels of agreement between the different ACEs reported prospectively by caregivers when compared to young adults' retrospective reports, with the exception of physical and sexual abuse and exposure to IPV which showed high levels of concordance. A study on prospective mother reports and retrospective adolescent reports found similar results of moderate agreement when looking at physical abuse [183].

When comparing levels of agreement and concordance rates on the ACEs that were reported at age 11 by both the caregiver and the adolescent, the results similarly have low kappa values. There is high concordance between caregiver and child on divorce/separation and child separation. Both caregiver and child more or less agree on relatively low levels (absence) of divorce/separation in the home, and the presence of prolonged child separation. Findings in this study suggest that there is some concordance on specific ACEs whether or not they are reported as present or absent. One study found that, when comparing mother and offspring accounts of a

range of adverse experiences, the two accounts tended to correspond when the adversity was absent [167]. The lowest concordance is found on chronic unemployment with adolescents reporting much lower levels of chronic unemployment in the household than caregivers at the same time. This raises issues around the type of ACEs different sources are able to report on; younger adolescents may be unaware of financial issues and the socio-economic status of the household in early childhood. Still, little research has been conducted on parents', particularly mothers', ability to provide a reliable account of their children's experiences in childhood. For a number of reasons parents may intentionally or unintentionally minimize adverse events in a child's life [184]. A study looking at mother and offspring retrospective reports of a range of childhood adversities found that mothers tend to under-report the frequency and severity of adverse events in their offspring's childhood [167]. In a similar study, Henry and colleagues found overall low levels of agreement between prospective mother reports collected in a birth cohort and retrospective reports collected when the respondents were 18 [185]. Agreement was higher for more objective experiences such as residential moves, but much lower for psychosocial and family processes. In a study with a larger gap between reports, Offer and colleagues compared adolescent self-reports and retrospective reports at approximate age 48 and found significant differences between what adults remember about adolescence and what was reported in adolescence [186].

Overall the findings in this study suggest unreliability when prospective reports from longitudinal data are compared to retrospective reports. While concluding that retrospective reports in adult life of adverse experiences in childhood are sufficiently valid, a review of the evidence cautions that the recall of experiences that are open to a wide degree of interpretation and rely substantially on judgment are less satisfactorily reported than those that are linked to serious abuse, neglect and conflict [84]. Issues around the design of assessments used to elicit information about sensitive childhood experiences also affect the reliability of reports. In two studies that assessed childhood abuse using different measures, fairly high rates of agreement were found [165, 166]; and through examining longitudinal data on 46 childhood experiences, Yancura and Aldwin conclude that retrospective reports may be reliable subject to well-designed assessments [162]. Examining the prospective prevalence of different reported ACEs across a number of time points shows variation in the experiences of children. It is difficult to know to

what extent this variation reflects actual changes in circumstances or perceptions at different time periods. Prospective reporting may very much depend on current state or mood and retrospective reporting on disposition and life outcomes. Whether an experience becomes part of an individual's life story, to be reported on retrospectively, depends on a number of factors both at the time of the experience and in the years following it. Research suggests that these life stories are not shaped until the post-adolescent years [187], and may not be stable until middle age [101]. Another view is that retrospective and prospective approaches address fundamentally different questions. While a prospective design examines what proportion of children exposed to adverse experiences go on to develop negative outcomes, a retrospective design assesses what proportion of individuals presenting negative outcomes report exposure to adverse childhood experiences [169]. With this in mind, it is less an issue of which design is more valid or reliable, but which is better suited to the particular inquiry.

3.4.4. Study limitations

One limitation in the data is that questions probing adverse childhood experiences throughout the study were not phrased in exactly the same way at every wave of data collection. The ability to analyse agreement between sources of reporting was also limited given that there was overlap with caregiver and adolescent reports of ACEs on only a few variables at the 11-year time point.

3.5. Conclusion

As family structures change and new environments are open to children, their experiences and their understanding of these experiences are altered. Well-designed assessments of prospective and retrospective childhood experiences help to closely capture an account of what children experience over a given period. But our individual awareness, understanding and state during and after life events play a large role in what is recalled or reported. Alluding to a quote by Offer and colleagues [186], retrospective reports may be considered “existential reconstructions” of childhood, subject to a life story that fluctuates over the life course. The challenge is to identify which account of a life story has bearing on future outcomes, and to appreciate that the level of validity and reliability of an account depends, to some extent, on the purpose of inquiry.

Overall, South African children are exposed to a large number of different ACEs throughout childhood. Their retrospective recall of these experiences in young adulthood differs substantially from what is reported prospectively. In addition to more research on the reliability

and validity of different reporting methods, multidisciplinary research is needed to explore how processes of memory formation and stress responses to physical and socioemotional context, particularly in the adolescent brain, affect the perception and recall of experiences located in childhood. Both prospective and retrospective accounts of adverse childhood experiences should be understood within these parameters, and used to answer research questions appropriate to their function. Retrospective reports may be valuable in eliciting information about experiences that remain with us after certain periods of time while prospective reports may be critical for understanding the mechanisms that determine health and wellbeing outcomes based on contemporaneous experiences, regardless of later recall.

CHAPTER 4: THE IMPACT OF ACES ON MENTAL HEALTH

Secondary analysis of retrospective and prospective reports of adverse childhood experiences and mental health in young adulthood: Filtered through recent stressors

4.1. Introduction

A large body of research documents associations between ACEs and health and well-being [25]. Risk factors for chronic disease including overweight and obesity [40, 41], and smoking [1, 43] have been linked to ACEs. The Kaiser ACE study found that as the number of exposures to ACEs increased, so did the prevalence and risk of, amongst others, alcoholism, use of illicit drugs, risky sexual behaviour and having a history of a sexually transmitted infection [19]. Growing evidence suggests that ACEs are inter-related [15]; for example, childhood sexual abuse often occurs in the presence of other ACEs [16], emphasizing the need for ACEs to be assessed comprehensively.

Environmental, socioeconomic and behavioural exposures, whether independent or clustered together, can be compounded over time to manifest in an accumulation of risk, which can affect adult health and wellbeing either through cumulative damage over time or by the biological embedding of adversities during sensitive developmental periods [188, 189]. The value of the ACE score, the total number of ACEs to which an individual reports having been exposed, lies in the ability to examine the cumulative impacts of ACEs on later life outcomes. The evidence describes the relationship between the extent of ACEs and social and health problems as one that predicts the risk to increase in a strong and graded manner as the number and severity of ACEs increase. Growing evidence shows that some ACEs – and some combinations – have a more deleterious effect on health and well-being than others [190], and may possibly have differential effects on different outcomes. For example, one study linked a cluster of ACEs related to abuse and neglect to higher severity bipolar disorder and schizophrenia, compared to a cluster of social support-related ACEs [191]. In another study on the clustering of individual ACEs, a child maltreatment and peer victimization group was associated with double the odds of self-rated poor physical health and three times the odds of self-rated poor mental health, compared to a household challenges grouping which was linked to an almost 3-fold chance of reporting poor physical health and six-times odds of reporting poor mental health [192].

In addition to the clustering and relative weight of certain ACEs, the method of data collection – essentially the timing of reporting – has been explored. Studies have found low to moderate agreement between prospective and retrospective ACEs, depending on the type of ACE [179, 193], and have also found differential associations with outcomes. One such study found that while prospective and retrospective reports showed associations with outcomes in midlife, retrospectively reported ACEs showed stronger associations with outcomes that were subjectively assessed compared to those objectively assessed [179]. Further complexity abounds when the nature of prospective reports is examined; while these are taken to be near contemporaneous accounts of events, prospective data is often still recalled or reported by participants, or in the case of young children, caregivers. Prospective accounts such as court records of abuse or substantiated cases of adversity are considered objective but are challenging to integrate into research for a number of reasons; they also represent only a proportion of real cases – those considered serious enough to go through the child protection system, and those that are actually reported [194]. However, emerging evidence points to the association of retrospective reports with negative outcomes, including psychopathology, even when there are inconsistencies with objective evidence of adversity [179, 195].

Moreover, recent life stress has been hypothesized to play some role in the relationship between early adversity and adult outcomes. Theories put forward include the dysregulation of stress response systems which result in maladaptive responses to subsequent stress or the increase in risk for future adversity based on exposure to adversity in childhood [196, 197]. Findings from the Bt30 cohort show that high levels of adult stress significantly increased the likelihood of psychological distress for those with high levels of ACEs, and posit a possible mediation effect between ACEs and psychological distress [61]. A number of studies have linked ACEs to poor mental health in adulthood [4, 26, 30, 177, 198]. The long-term effects of ACEs on mental health during the early adult years in low-middle-income settings have been understudied and where they have, most studies include clinical or cross-sectional samples [37]. Studies that have been conducted confirm the relationship between exposure to ACEs and poor adult mental health [199].

The aim of this study is to assess the associations of prospectively and retrospectively reported accounts of ACEs to the mental health of a young adult sample from a peri-urban, historically

disadvantaged South African context. In addition, this study will explore potential mediating or moderating effects of recent stressors on the relationship between ACEs and mental health outcomes. The study will contribute to the ACEs literature by exploring how different approaches to ACEs measurement – single, cumulative and prospective versus retrospective, can be associated with mental health outcomes in a young adult sample. Clarity on the timing, type and number of ACEs that are linked to persistent negative outcomes is critical for the development of appropriate interventions, particularly in contexts like South Africa where there exists a large gap between the burden of mental health problems and the resources available to address it [200].

Research in Context

Evidence before this study

Experiences of adversity in childhood have been linked to increased risk of poor mental health outcomes in later life, with less evidence in the young adult population. Results from previous analyses show the prevalence of reported ACEs vary when assessed prospectively and retrospectively in the same sample, however the evidence in LMICs is scarce. Adult stress, independent of early adversity, has been linked to mental health problems, but is also hypothesized to act in conjunction with histories of adversity to either sensitize individuals to future stressors, disrupt coping strategies or aggravate negative mental health outcomes.

Added value of this study

The findings of this study indicate that the timing, type and number of reported ACEs work together to impact on mental health outcomes in young adulthood. Both prospective and retrospective reporting of four or more ACEs are associated with poor mental health, even though the prevalence of retrospective reports of individual ACEs decreases over time. When adjusted for the number of recent stressors, the likelihood of overall psychological distress increases as the number of ACEs increases.

Implication of all the available evidence

While the concept of ACEs constitutes a range of negative exposures for children (1) some are more deleterious on mental health in young adulthood, independent of others, (2) the cumulative risk of ACEs should not be ignored since poor mental health in young adulthood is also associated with the total number of ACEs reported, and (3) females report exposure to a similar number of adverse childhood experiences prospectively and fewer retrospectively than their male counterparts but are at twice the risk of poor mental health.

4.2. Methods

4.2.1. Study design and participants

The Bt30 cohort is a South African birth cohort of 3,273 singleton children born to mothers who were residents of Soweto-Johannesburg in a 7-week period of enrolment in 1990. The study is unique in that it is the largest and longest running study of child and adolescent health and development in Africa. Current participants are 32 years old, have been assessed up to 22 times and, since 2005 when the first participant birth occurred, includes the 3rd generation of the

cohort. A detailed description of the study, its birth cohort and participants is published elsewhere [102][29]. This study uses data from birth to age 22 for prospective and retrospective reports of ACEs, and covers the period between 1990 and 2013. A total of 1,636 participants were surveyed at the 22-year wave and a sample of 1,592 participants from this group that had both retrospective and prospective reports of ACEs was included in this analysis. Ethical clearance was obtained from the Witwatersrand University Committee for Research on Human Subjects (M140726). All participants and/or their caregivers gave informed written consent for the data reported.

4.2.2. Procedures

Adverse childhood experiences and recent stressors

ACEs have been defined as physical abuse, sexual abuse, emotional abuse and/or neglect, child separation, divorce or parent separation, parent death, exposure to violence, exposure to intimate partner violence (IPV), chronic unemployment, household substance abuse, household legal trouble, household serious illness or disability, and household death. The ACEs survey questions are included in Appendix 1. For prospective reports, caregivers were asked to report on their children at participant ages 5, 7 and 11, and participants provided self-reports at ages 11, 15 and 18. A participant was recorded as having experienced a particular ACE if there was a positive response at any one of these time points. For the retrospective report, participants were asked at the 22-year wave to indicate if they had experienced each of the ACEs during the first 18 years of their life. A full detailed account of individual ACEs reported at each of the 7 time points, as well as an analysis of the level of agreement between sources and timing, has been published [193]. In summary, that analysis found the reports of prospective and retrospective ACEs, used in this study, had little overall agreement; 80% of the kappa values were below the moderate agreement cut-off of k=0.41. The highest levels of agreement were between reports on parental death (k=0.52) and household death (k=0.51). Reporting on early life ACEs by caregivers (at ages 5, 7 and 11) showed the greatest concordance with retrospective reports of ACEs on sexual abuse (91.0% agreement), physical abuse (87.7% agreement), and exposure to intimate partner violence (80.2% agreement) [193].

For the purposes of this paper, we conceptualise the ACEs directly impacting an individual – physical, sexual, and emotional abuse – as proximal ACEs, and those occurring in their

environment – exposure to IPV, household illness, chronic unemployment – as distal ACEs. For ease of reading, retrospectively reported ACEs may be referred to as 'retrospective ACEs' and vice versa; similarly, for individual ACEs we may use the shorthand 'prospective physical abuse' rather than 'prospectively reported physical abuse' but the method of data collection for all ACEs is either self-reported or parent-reported (in the case of children under the age of 7 years).

An assessment of recent stressors, adapted from the Township Life Event Scale [201], was added to the analysis. Participants were asked at the 22-year data collection wave to indicate if they had experienced any of 9 negative life events – considered stressors – in the past 6 months. The 9 events included violence in the household (1), workplace (2) or community (3), household illness (4), disability (5) or death (6) in the family, household substance abuse (7), alienation from family (8), and legal (9). Full questions are available in Appendix 1.

Mental health outcomes

Young adult mental health was assessed using the self-reported GHQ-28 which comprises 4 sub-scales of 7 items each probing for somatic symptoms, anxiety and insomnia, social dysfunction, and major depression. The 28 items are scored in a binary 0011 method. Higher scores on the GHQ-28 represent higher levels of psychological distress. The GHQ-28 is used in epidemiological studies as a screening for minor psychiatric morbidity caseness (clinically significant anxiety and/or depression). Any score above 4 on a subscale and above 23 on the total scale indicates the presence of distress or a positive diagnostic [202]. The GHQ questions are available in Appendix 2.

4.2.3. Statistical analysis

Data was analysed using STATA statistical software version 13.0. The ACEs data were transformed into a retrospective and a prospective categorical score for each participant as follows: 0= 'no reported ACEs', 1= 'one reported ACE', 2= 'two reported ACEs', 3= 'three reported ACEs' and 4= 'four or more reported ACEs'. In parts of the analyses outcomes are compared between 'less than four' and 'four or more' reported ACEs. There are currently no guidelines on the ACEs scoring in the available literature but some studies do point to the 'four or more' cut-off functioning as a threshold level, with noticeable deviations in a range of outcomes at that mark [19, 203].

The four mental health outcomes, somatization, anxiety, social dysfunction, and depression were transformed into categorical data and the co-occurrence of psychological distress with reports of ACEs was evaluated using the chi-square statistic. Unadjusted effects of each individual ACE, followed by each composite measure of ACEs, separately for prospective and retrospective ACEs, were tested for effects on somatization, anxiety, social dysfunction, depression and GHQ total. Five adjusted logistic regression models were fitted including significant predictors from the unadjusted models, controlling for sex, SES, maternal education and recent stressors, to estimate the association between the ACE scores and each outcome. Odds ratios and 95% confidence intervals were calculated separately for each outcome. In the fully adjusted models, retrospective and prospective ACEs are entered in the same model together with the selected covariates, therefore the odds ratios for prospective ACEs indicate the contribution of prospective ACEs independently from retrospective ACEs and vice versa. Factorial analysis of variance was used to test for the unique contribution of prospective and retrospective reports of ACEs, as well as any interactions between them, to the variance in each mental health outcome.

Regression analysis was used to test for mediation and moderation effects of recent stressors on mental health outcomes. Factorial analysis of variance tested for interaction effects between retrospectively and prospectively reported ACEs and recent stressors on psychological distress. These analyses yielded no significant results and the recent stressors were subsequently added to the regression models as a covariate.

4.3. Results

4.3.1. Sample and data description

Of the initial 3,273 participants recruited in 1990, 1,636 were surveyed at the 22-year wave in 2017, representing a loss to follow-up of 50%. ACEs data was available for 1,592 of the 1,636 participants surveyed in 2013, the remaining 42 participants were not included in this analysis. A description of sample demographics at recruitment and at the 22-year wave, by sex, is shown in Table 9.

ACE scores were computed for each participant who had data for at least 10 of the 13 ACEs; those with fewer than 10 – or 3 or more missing data points – were excluded from the analytic dataset. For prospective data, missing data was imputed from previous and subsequent waves of data, excluding the retrospective data, to compose comprehensive accounts. In the retrospective

data, all variables except for parental divorce (17%) had less than 10% missing values. The analysis was restricted to cases with data on the exposures, only cases with data for both prospective and retrospective ACEs were included. Missing data ranged from 1.07% to 3.52% on outcome variables, and between 0.19% and 7.91% on the covariates (Appendix 8, Table 4A). The distribution of ACEs among cases with data was not substantially different from those cases without data on a specific variable, and significant differences are due to the small number of missing cases (Appendix 8, Table 4B). The largest proportions of missing data were among covariates (up to 7.91%) and these cases were dropped through listwise deletion during the regression analyses. Given the relatively small proportions of missing data, and the comprehensiveness of ACE data, no further handling of missing data was done and all analyses assumes data are missing at random, which the authors concede is a limitation.

4.3.2. Prevalence of ACEs

Table 10 shows the frequency of ACEs by source of report and sex. Exposure to individual ACEs is summed to create an ACE score. Changes in the prevalence of ACEs by report (prospective versus retrospective) and source (self- versus parent-) in this cohort has been explored in greater detail in a previous publication [14] and are summarized in the methods section. The proportion of participants who report experiencing four or more ACEs drops by more than half, from 87.4% to 38.0%, when reported retrospectively compared with prospective reporting. The prevalence of all ACEs decreases from prospective to retrospective reporting, with the exception of reports of parental death which increases from 22.4% to 27.9%. The greatest decreases are in reports of physical and sexual abuse (87% and 90% decrease, respectively), exposure to violence inside and outside of the household (73% and 61% decrease, respectively), and chronic unemployment in the household (49% decrease). Reports of emotional abuse/neglect are much the same regardless of when it is reported, with 36.2% prospectively and 34.7% retrospectively. Overall, individuals tend to report fewer ACEs retrospectively than they do prospectively, with 12.5% of participants reporting fewer than four ACEs prospectively compared to 62.0% retrospectively.

Table 9: Demographic profile of sample at baseline and at 22-year wave, by sex

Source of report	Baseline[a]			22-year wave[b]		
	Total N (%)	Male N (%)	Female N (%)	Total N (%)	Male N (%)	Female N (%)
Marital status						
Married or cohabitating	558 (35.3)	282 (37.1)	276 (33.6)	786 (50.2)	340 (45.2)	446 (54.9)
Single or separated	1024 (64.7)	479 (62.9)	545 (66.4)	779 (49.8)	412 (54.8)	367 (45.1)
Education						
No formal education	193 (13.1)	97 (13.8)	96 (12.5)	0 (0)	0 (0)	0 (0)
Primary school	687 (46.5)	337 (47.8)	350 (45.4)	3 (0.2)	1 (0.2)	2 (0.3)
Secondary school	492 (33.3)	221 (31.4)	271 (35.2)	942 (70.0)	398 (69.6)	544 (70.4)
Post-school education	104 (7.1)	50 (7.1)	54 (7.0)	400 (29.7)	173 (30.2)	227 (29.4)
Socioeconomic status[a]						
Quintile 1	225 (15.4)	114 (16.2)	111 (14.5)	505 (32.8)	250 (33.7)	255 (31.8)
Quintile 2	269 (18.4)	130 (18.5)	271 (35.5)	242 (16.7)	117 (15.8)	125 (15.6)
Quintile 3	511 (34.9)	240 (34.2)	271 (35.5)	309 (20.0)	162 (21.9)	147 (18.4)
Quintile 4	297 (20.3)	148 (21.1)	149 (19.5)	272 (17.6)	118 (15.9)	154 (19.2)
Quintile 5	164 (11.2)	70 (10.0)	94 (12.3)	214 (13.9)	94 (12.7)	120 (15.0)
Adverse childhood experiences						
0	294 (23.1)	137 (22.9)	157 (23.2)	139 (8.7)	61 (43.9)	78 (56.1)
1	469 (36.8)	214 (35.8)	255 (37.7)	277 (17.4)	132 (47.7)	145 (52.3)
2	188 (14.7)	95 (15.9)	93 (13.7)	293 (18.4)	113 (38.6)	179 (61.4)
3	122 (9.6)	58 (9.7)	64 (9.5)	279 (17.6)	138 (49.5)	140 (50.5)
≥4	202 (15.8)	94 (15.7)	108 (16.0)	604 (38.0)	320 (53.0)	283 (47.0)

[a]Measure of maternal or household characteristics, [b]Measure of the participant's characteristics

Table 10: Prevalence of ACEs by report type and sex

Source of report	Prospective report			Retrospective report		
	Total N (%)	**Male N (%)**	**Female N (%)**	**Total N (%)**	**Male N (%)**	**Female N (%)**
Adverse childhood experiences						
Physical abuse	880 (55.3)	457 (51.9)	423 (48.1)	118 (7.4)	67 (56.8)	51 (43.2)
Sexual abuse	613 (38.5)	296 (48.3)	317 (51.7)	63 (4.0)	22 (34.9)	40 (65.1)
Emotional abuse/neglect	577 (36.2)	282 (48.9)	294 (51.1)	552 (34.7)	278 (50.4)	272 (49.6)
Child separation	244 (15.3)	105 (43.0)	139 (57.0)	-	-	-
Divorce/separation	816 (51.3)	382 (46.8)	434 (53.2)	593 (37.3)	283 (47.7)	309 (52.3)
Parental death	357 (22.4)	182 (51.0)	173 (49.0)	443 (27.9)	230 (51.9)	212 (48.1)
Exposure to violence	1,114 (70.0)	591 (53.0)	522 (47.0)	431 (27.1)	246 (57.1)*	184 (42.9)*
Exposure to IPV	750 (47.1)	422 (56.3)*	326 (43.7)*	202 (12.7)	93 (46.0)	108 (54.0)
Chronic unemployment	1,346 (84.5)	645 (47.9)	701 (52.1)	684 (43.0)	346 (50.6)	337 (49.4)
Household substance abuse	740 (46.5)	346 (46.8)	394 (53.2)	438 (27.6)	235 (53.7)	202 (46.3)
Household legal trouble	579 (36.4)	325 (56.1)*	254 (43.9)*	364 (22.9)	202 (55.5)	162 (44.5)
Household illness/disability	984 (61.8)	475 (48.3)	509 (51.7)	553 (34.8)	258 (46.7)	294 (53.3)
Household death	971 (61.0)	458 (47.2)	510 (52.8)	396 (24.9)	193 (48.7)	200 (51.3)
ACE score						
0	8 (0.5)	3 (37.5)	5 (62.5)	139 (8.7)	61 (43.9)	78 (56.1)
1	26 (1.6)	12 (46.2)	14 (53.8)	277 (17.4)	132 (47.7)	145 (52.3)
2	46 (2.9)	13 (28.3)*	31 (71.7)*	293 (18.4)	113 (38.6)*	179 (61.4)*
3	120 (7.5)	55 (45.8)	65 (54.2)	279 (17.6)	138 (49.5)	140 (50.5)
≥4	1,392 (87.4)	681 (48.9)	710 (51.1)	604 (38.0)	320 (53.0)	283 (47.0)
Total	**1592 (100.0)**	**764 (48)**	**825 (52)**	**1589 (100.0)**	**764 (48.1)**	**825 (51.9)**

*$p<.001$ – significant differences between males and females

Categories for ACEs found in the literature were compared across socio-demographic variables (Table 11). Significant differences are indicated by asterisk. In both prospective and retrospective reporting of ACEs, a significantly higher proportion of children living in households with single or separated parents report four or more ACEs (p=0.14). Similarly, higher maternal education appears to be associated with fewer reported ACEs both retrospectively and prospectively (p=0.006). Males and females tend to report similar numbers of ACEs prospectively. However, the number of males who report four or more ACEs retrospectively is significantly higher (p=0.001). More participants in higher socio-economic quintiles report fewer ACEs both retrospectively and prospectively.

4.2.3. Associations between ACEs and mental health outcomes

Table 12 shows the distribution of mental health outcomes for ACEs reported prospectively and retrospectively, categorized as 'less than four' or 'four or more'. Given patterns in the literature associating adversity in childhood with poor mental health [191, 192], it is expected that a greater proportion of respondents who report four or more ACEs will present with psychological distress. Using prospective reports of ACEs there appears to be little significance between reported ACEs and psychological distress (somatization, p=0.465; anxiety, p=0.263; social dysfunction, p=0.522; depression, p=0.050; GHQ total, p=0.273). Using the retrospective reports, there are significant differences in the expression of psychological distress between respondents who report less than four or four or more ACEs on all mental health outcomes (p=0.000), apart from social dysfunction (p=0.360). Adding both reports into one model per outcome, we explore the relative contribution of prospective and retrospective reports of ACEs to the variance in each outcome (Appendix 8, Table 4C). Significant models were found for somatization [$F(3, 1570) = 7.18$, p=0.000], anxiety [$F(3, 1570) = 25.31$, p=0.000], depression [$F(3,1570) = 26.13$, p=0.000], and total GHQ [$F(3, 1532) = 20.73$, p=0.000], but not for social dysfunction [$F(3, 1571) = 0.45$, p=0.7160]. For somatization, only retrospective ACEs have a significant main effect (p=0.000) with no interaction effect. Similarly, for anxiety and total GHQ, retrospective ACEs are the only main effect (p=0.000) with no interaction effect. There are no significant main or interaction effects for social dysfunction (p=0.518 for prospective ACEs, p=0.503 for retrospective ACEs, and p=0.736 for their interaction).

Table 11: ACE profiles by demographic variables

	None N (%)	One N (%)	Two N (%)	Three N (%)	Four or more N (%)	Total N (%)
Prospective Report Total	**8 (0.5)**	**26 (1.6)**	**46 (2.9)**	**120 (7.5)**	**1392 (87.4)**	**1592 (100.0)**
Maternal marital status						
Married or cohabitating	5 (71.4)	10 (40.0)	19 (43.2)	55 (45.8)	469 (33.8)*	558 (35.3)
Single or separated	2 (28.6)	15 (60.0)	25 (56.8)	65 (54.2)	917 (66.2)*	1024 (64.7)
Maternal education						
No formal education	0 (0.0)	2 (8.0)	3 (7.5)	16 (14.4)	172 (13.3)	193 (13.1)
Primary school	0 (0.0)*	5 (20.0)*	19 (47.5)	52 (46.8)	611 (46.5)	687 (46.5)
Secondary school	5 (71.4)*	16 (64.0)*	14 (35.0)	32 (28.8)	425 (32.9)	492 (33.3)
Post-school education	2 (28.6)*	2 (8.0)	4 (10.0)	11 (9.9)	85 (6.6)	104 (7.1)
Sex						
Male	3 (37.5)	12 (46.2)	13 (29.5)*	55 (45.8)	681 (49.0)	764 (48.1)
Female	5 (62.5)	14 (53.8)	31 (70.5)*	65 (54.2)	710 (51.0)	825 (51.9)
Socioeconomic status[a]						
Quintile 1	0 (0.0)	4 (18.2)	6 (15.4)	20 (17.5)	192 (15.2)	225 (15.45)
Quintile 2	2 (28.6)	5 (22.7)	5 (12.8)	14 (12.3)	243 (18.9)	269 (18.4)
Quintile 3	1 (14.3)	3 (13.6)	17 (43.6)	38 (33.3)	452 (35.2)	511 (34.9)
Quintile 4	3 (42.9)	6 (27.3)	5 (12.8)	22 (19.3)	261 (20.3)	297 (20.3)
Quintile 5	1 (14.3)	4 (18.2)	6 (15.4)	20 (17.5)*	133 (10.4)*	164 (11.2)
Retrospective Report Total	**139 (8.7)**	**277 (17.4)**	**293 (18.4)**	**279 (17.5)**	**604 (37.9)**	**1592 (100.0)**
Maternal marital status						
Married or cohabitating	59 (43.1)	116 (41.9)*	100 (34.6)	95 (34.2)	188 (31.3)*	558 (35.3)
Single or separated	78 (56.9)	161 (58.1)	189 (65.4)	183 (65.8)	413 (68.7*)	1024 (64.7)
Maternal education						
No formal education	15 (11.8)	37 (14.2)	29 (10.6)	385 (14.6)	74 (13.3)	193 (13.1)
Primary school	42 (33.1)*	111 (42.7)	127 (46.5)	118 (45.4)	289 (52.0)*	687 (46.5)
Secondary school	55 (43.3)*	90 (34.6)	103 (37.7)	86 (33.1)	158 (28.4)*	492 (33.3)
Post-school education	15 (11.8)*	22 (8.5)	14 (5.1)	18 (6.9)	35 (6.3)	104 (7.1)
Sex						
Male	61 (43.9)	132 (47.7)	113 (38.7)*	138 (49.6)	320 (53.1)*	764 (48.1)
Female	78 (56.1)	145 (52.3)	179 (61.3)*	140 (50.4)	283 (46.9)*	825 (51.9)
Socioeconomic status[a]						

	None N (%)	One N (%)	Two N (%)	Three N (%)	Four or more N (%)	Total N (%)
Quintile 1	14 (11.1)	37 (14.3)	31 (11.3)	41 (15.9)	102 (18.6)*	225 (15.4)
Quintile 2	23 (18.3)	39 (15.1)	53 (19.3)	48 (18.6)	106 (19.3)	269 (18.4)
Quintile 3	39 (31.0)	93 (36.0)	95 (24.5)	89 (34.5)	195 (35.5)	511 (34.96)
Quintile 4	32 (25.4)	56 (21.7)	62 (22.5)	43 (16.7)	104 (18.9)]	297 (20.3)
Quintile 5	18 (14.3)	33 (12.8)	34 (12.4)	37 (14.3)	42 (7.7)*	164 (11.2)

[a]in quintiles with increasing SES differences between ACE scores

*$p<.05$ – significant

Table 12: Distribution of mental health symptoms for reported ACES

Mental health outcome	Prospective report (%)			Retrospective report (%)		
	Less than 4	Four or more	Sig.	Less than 4	Four or more	Sig.
Somatization						
Below cut-off	125 (63.8)	887 (64.4)	.465	658 (67.7)	354 (58.8)	.000
Above cut-off	71 (36.2)	491 (35.6)		314 (32.3)	248 (41.2)	
Anxiety						
Below cut-off	113 (57.7)	831 (60.3)	.263	650 (66.9)	294 (48.8)	.000
Above cut-off	83 (42.3)	547 (39.7)		322 (33.1)	308 (51.2)	
Social dysfunction						
Below cut-off	82 (41.8)	576 (41.8)	.522	410 (42.2)	248 (41.1)	.360
Above cut-off	114 (58.2)	803 (58.2)		562 (57.8)	355 (58.9)	
Depression						
Below cut-off	174 (88.8)	1160 (84.2)	.055	865 (89.0)	469 (77.9)	.000
Above cut-off	22 (11.2)	218 (15.8)		107 (11.0)	133 (22.1)	
GHQ Total						
Below cut-off	145 (75.5)	983 (73.1)	.273	755 (78.8)	373 (64.5)	.000
Above cut-off	47 (24.5)	361 (26.9)		203 (21.2)	205 (35.5)	

For depression, both prospective and retrospective ACEs have significant main effects at the p=0.000 level, slightly stronger for retrospective ACEs (eta^2=0.0266) compared to prospective ACEs (eta^2=0.0122), and a significant interaction effect (p=0.0440). Overall, the results indicate that composite measures of retrospective ACEs are associated with somatization, anxiety and the total GHQ; while both prospective and retrospective ACEs contribute to depression. In addition, reporting above the mean (2.5) prospective ACEs and more than four retrospective ACEs is associated with increased scores on depression.

Figures 18-22 illustrate the odds ratios for each adjusted model, or the fold-increase in the odds of experiencing levels of psychological distress given reports of retrospective and prospective ACEs and additional covariates, including recent stressors. Results from the unadjusted and adjusted stepwise regressions are included in Appendix 8 as Tables 4D and 4E. Irrespective of ACEs, females report significantly higher levels of poor mental health (anxiety: OR 2.4 [95% CI 1.84-3.01, p=0.000]; somatization: OR 2.2 [95% CI 1.72-2.76, p=0.000]; social dysfunction: OR 1.5 [95% CI 1.22-1.88, p=0.000]; depression: OR 2.8 [95% CI 1.99-3.89, p=0.000]; total GHQ: OR 2.6 [95% CI 2.02-3.43, p=0.000]). No other socio-demographic variables included here significantly account for variations in mental health outcomes; apart from in the social dysfunction subscale, where only socio-demographic variables contribute to increased risk for greater social dysfunction.

A number of individual ACEs are associated with an increased risk for psychological distress. Retrospective emotional abuse/neglect is associated with increased anxiety (OR 1.8 [95% CI 1.32-2.36, p=0.000]), depression (OR 1.6 [95% CI 1.08-2.25, p=0.018]) and psychological distress in general (OR 1.6 [95% CI 1.18-2.17, p=0.002]), while prospective emotional abuse/neglect is linked to increased psychological distress (OR 1.3 [95% CI 1.04-1.63, p=0.034]). Retrospective exposure to severe household illness/disability is associated with increased somatization (OR 1.5 [95% CI 1.14-1.92, p=0.004]); and retrospective exposure to IPV is associated with increased somatization (OR 1.7 [95% CI 1.19-2.46, p=0.002]) and anxiety (OR 1.6 [95% CI 1.12-2.37, p=0.010]). Both prospective physical and sexual abuse are associated with an increased risk of depression (OR 1.7 [95% CI 1.37-1.93, p=0.034], and OR 1.8 [95% CI 1.27-2.07, p=0.018], respectively). Prospective chronic household unemployment is

associated with a decreased risk of somatization (OR 0.7 [95% CI 0.50-.99, *p*=0.048]) and anxiety (OR 0.6 [95% CI 0.45-.91, *p*=0.013]).

When looking at cumulative ACEs retrospectively, the greater the number of reported ACEs, the greater the risk for anxiety (OR 1.9 [95% CI 1.27-2.83, *p*=0.002]), somatization (OR 1.5 [95% CI 1.14-2.06, *p*=0.004]), depression (OR 1.6 [95% CI 1.07-2.31, *p*=0.021]), and reporting four or more ACEs is associated with a greater than twofold increase in risk for somatization and overall psychological distress (OR 2.7 [95% CI 1.42-3.53, *p*=0.003], and OR 2.2[95% CI 1.58-3.12, *p*=0.008], respectively).

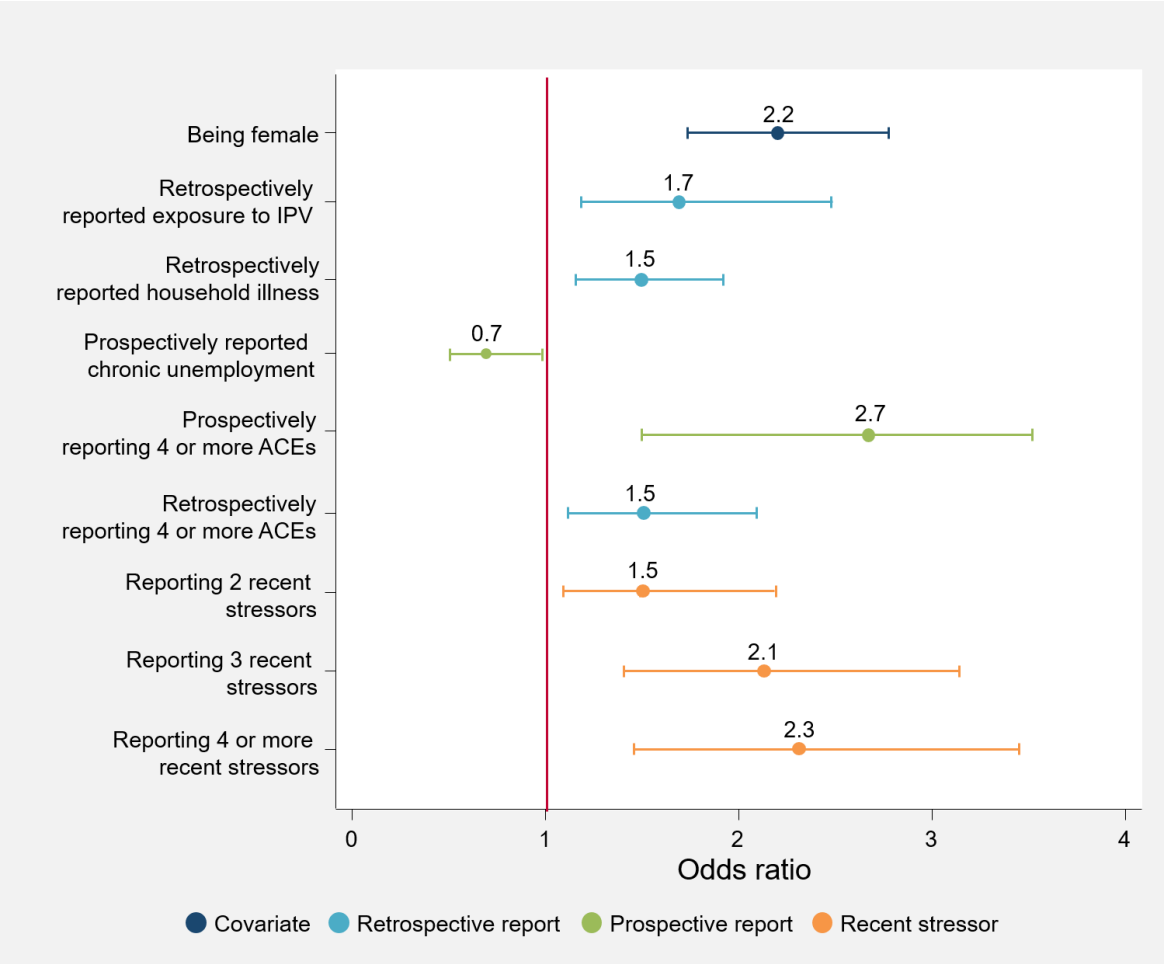


Figure 20: Adjusted effects of reported ACEs and covariates on somatization

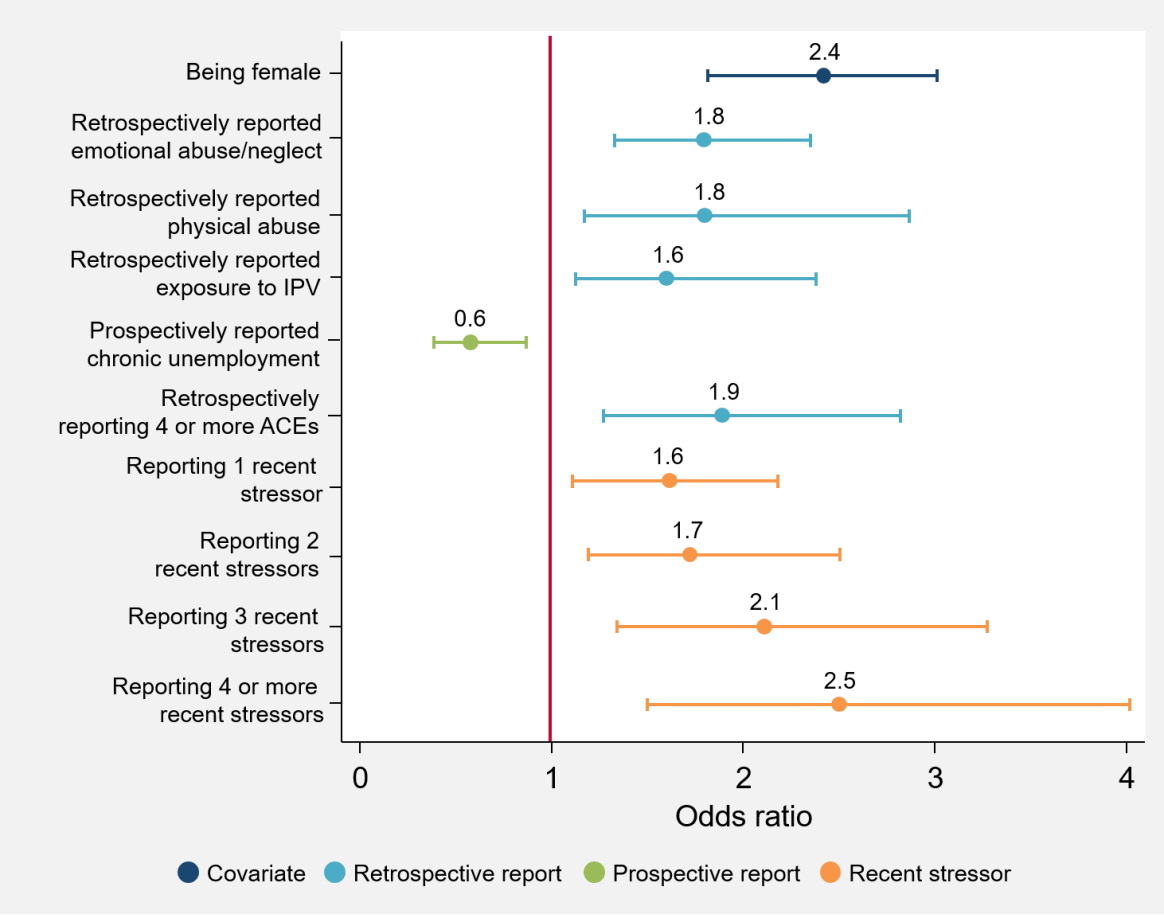


Figure 21: Adjusted effects of reported ACEs and covariates on anxiety

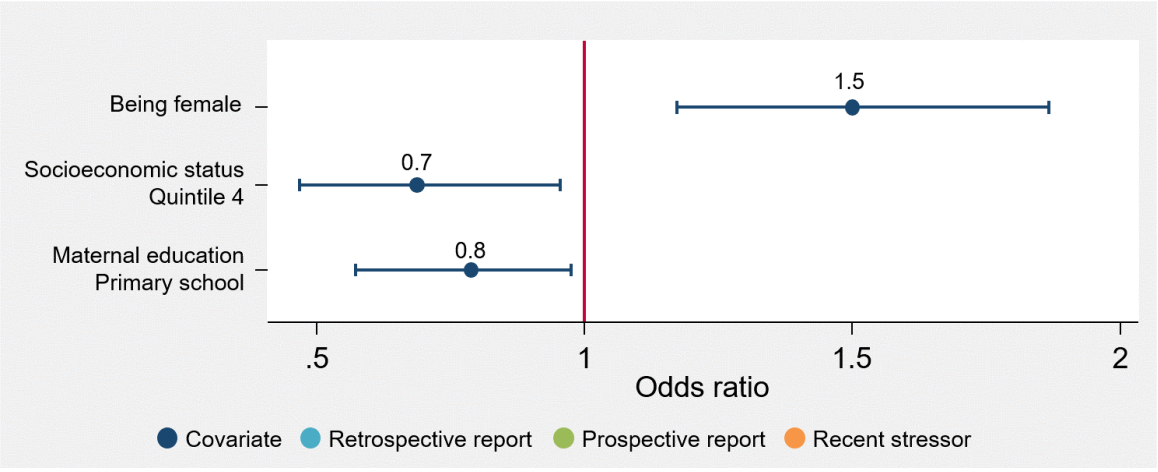


Figure 22: Adjusted effects of reported ACEs and covariates on social dysfunction

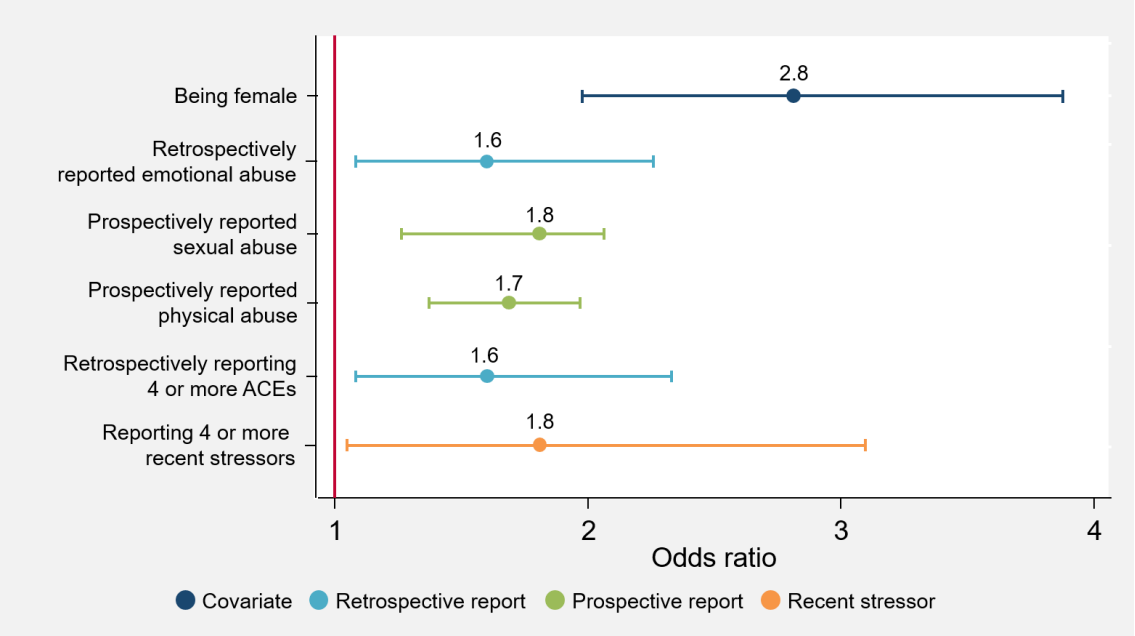


Figure 23: Adjusted effects of reported ACEs and covariates on depression

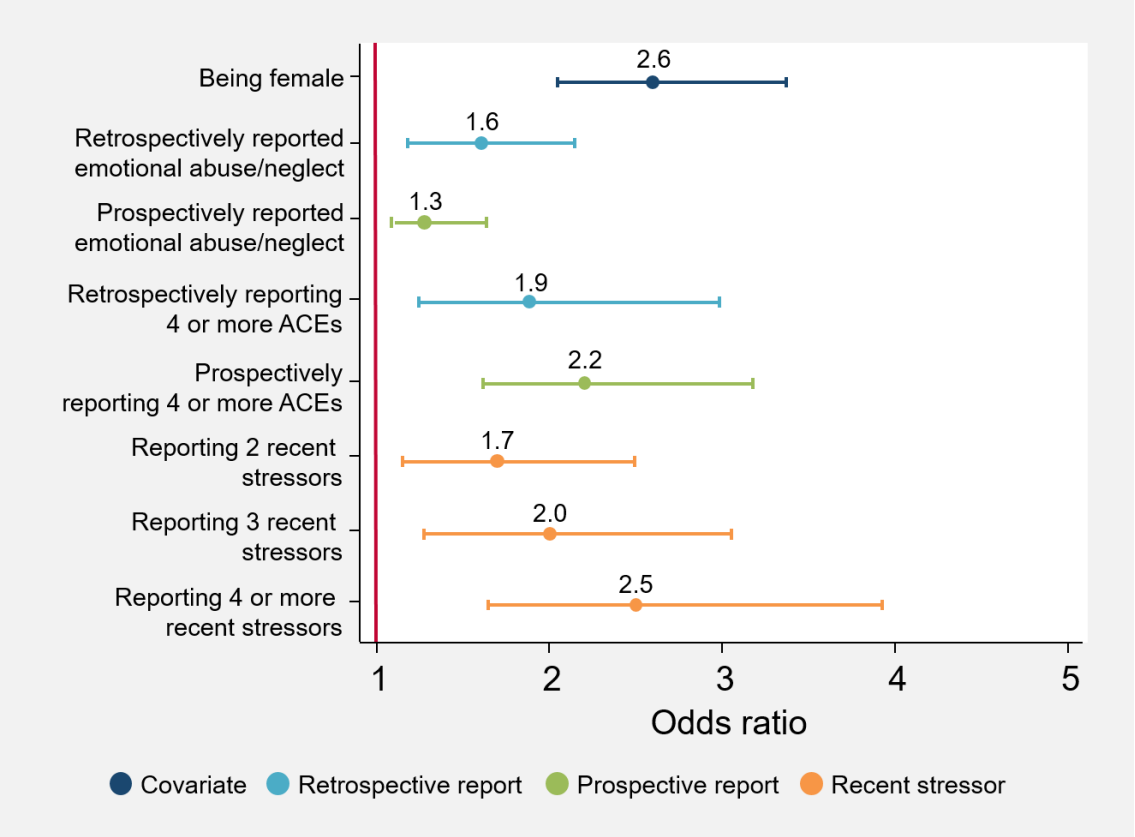


Figure 24: Adjusted effects of reported ACEs and covariates on the total GHQ score

4.2.4. The influence of recent stressors

Reports of recent stressors show a strong and graded influence on anxiety, somatization, depression and overall psychological distress. The higher the number of recent stressors reported the greater the risk for negative mental health outcomes; the odds of experiencing somatization, anxiety and overall psychological distress more than doubling when four or more recent stressors are reported (OR 2.3 [95% CI 1.47-3.47, p=0.000], OR 2.5 [95% CI 1.50-4.12, p=0.000], and OR 2.5 [95% CI 1.63-3.96, p=0.000], respectively). Recent stressors have a slightly weaker influence on depression but still increase the odds (OR 1.8 [95% CI 1.05-3.13, p=0.034]). When accounting for recent stressors, adjusted odds ratios between retrospective ACEs and mental health outcomes decrease, suggesting that recent stressors independently contribute to poor mental health outcomes, but may well bias retrospective recall itself.

Factorial analysis of variance examining the effects of recent stressors and ACEs on psychological distress (Appendix 8, Table 4C) yielded significant models for both prospective ACEs [$F(9, 1505) = 8.35$, p=0.000)] and retrospective ACEs [$F(9, 1505) = 10.11$, p=0.000)]. For the prospective model, recent stressors (p=0.000) and prospective ACEs (p=0.023) were independently and significantly associated with psychological distress, but there was no significant interaction between recent stressors and prospective ACEs (p=0.501). For the retrospective model, recent stressors (p=0.000) and retrospective ACEs (p=0.000) were independently and significantly associated with psychological distress, but again there was no significant interaction between recent stressors and retrospective ACEs (p=0.976).

Figure 25 and Figure 26 show the plotted analysis of variance results for the number of recent stressors reported in adulthood compared to the number of prospectively or retrospectively reported ACEs by psychological distress. The number of recent stressors reported in young adulthood appears to have less of an association with the number of ACEs prospectively experienced (Figure 25) compared to the association between the number of recent stressors and retrospective ACEs (Figure 26) where a steeper climb is apparent. For both retrospective and prospective ACEs, participants presenting with distress report on average more recent stressors than those not presenting with distress as the number of ACEs increases.

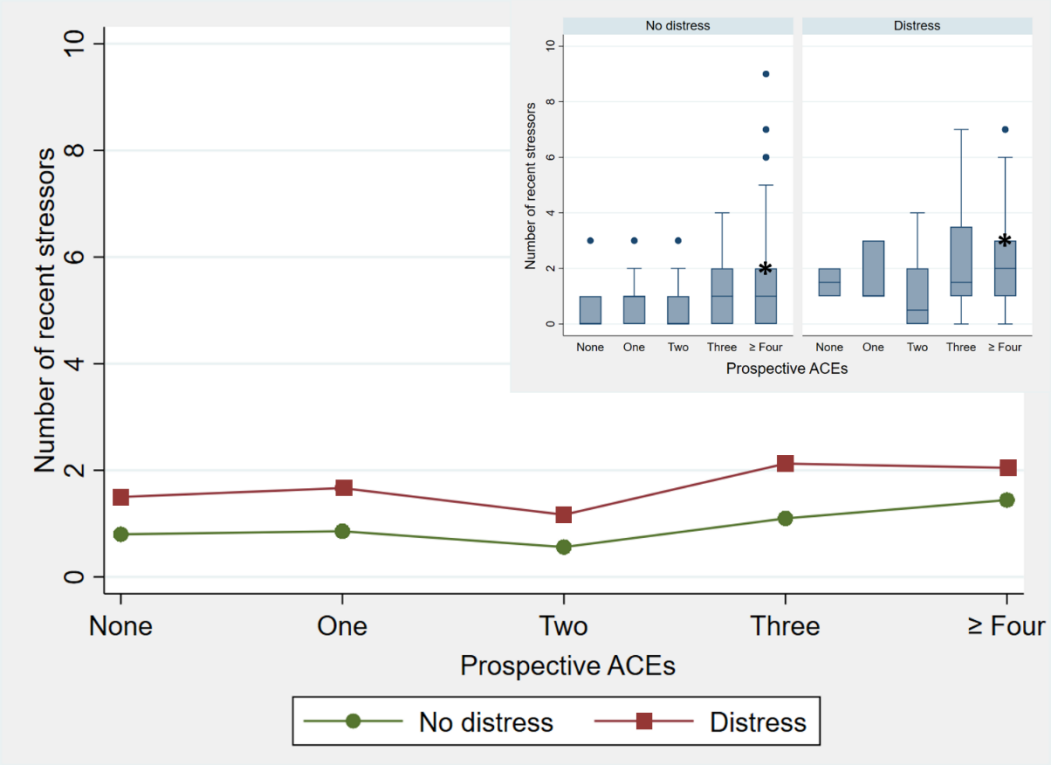


Figure 25: Comparison of the number of recent stressors by psychological distress for prospectively reported ACEs

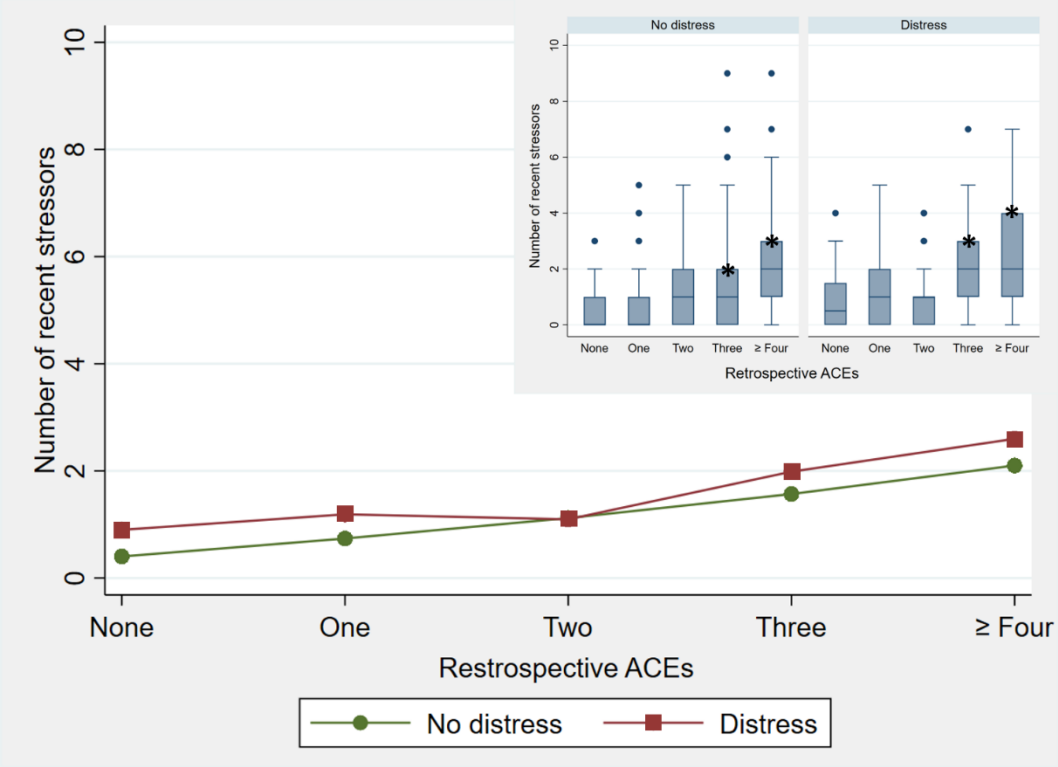


Figure 26: Comparison of the number of recent stressors by psychological distress for retrospectively reported ACEs

The inlaid boxplots in Figure 25 and Figure 26 show the variability in recent stressors across prospective and retrospective ACEs, with less variance in the number of recent stressors when participants report lower numbers of ACEs compared to when they report three or four or more ACEs. For prospective ACEs, the upper 25% of participants presenting with distress report on average higher numbers of recent stressors than their counterparts in each of the ACE categories. The same is true for retrospective ACEs, apart from a smaller group of participants who present with distress, report relatively low ACEs (two), and report between zero and two recent stressors.

4.4. Discussion

The number of ACEs reported does not appear to have any association with social dysfunction. Instead, sociodemographic variables such as sex, SES and maternal education account for the variations in the social dysfunction scale. Given the socio-political climate in South Africa, characterized by a poor education system – where about 60% of youth have either left school before graduation, or do not graduate [204], high youth unemployment rates, and resultant poverty, young adults may find themselves generally unprepared for functioning independently. This, and cultural issues specific to a young adult South African sample, could explain the contrasting findings on the social dysfunction subscale compared to the other subscales.

Extended to the other domains of the GHQ, the findings of this study indicate that both prospective and retrospective reports of ACEs can be linked to mental health in young adulthood. Young adults prospectively reporting four or more ACEs are more than twice as likely to experience psychological distress than those reporting less than four ACEs. While lower in prevalence than prospectively reported ACEs, retrospectively reported ACEs have a stronger association with anxiety, depression, somatization and general psychological distress in young adulthood. Similar studies have linked ACEs, individually and in combination, to mental health outcomes in general [37, 205] and the GHQ in particular [206]. Heim and colleagues propose that early adverse experiences not only contribute to the manifestation of some types of depression, as evidenced in this study, but likely influence treatment responses [207].

Distal ACEs like chronic household unemployment, household legal trouble and low socio-economic status do not appear to have persistent influence over the mental health of young adults in this sample. Research has shown that relative to a history of either no or high cumulative lifetime adversity, a history of some adversity is associated with better mental health and

wellbeing [208]. Counterintuitively, prospective chronic unemployment in the household appears to have a protective effect on somatization and anxiety in this study. The pervasiveness of adversity – in the distal form – throughout a community may in some sense lead to a 'normalization' of poverty and hardship that engenders a resilience in South African youth, mitigating its impact on mental health. In contrast, proximal ACEs such as physical, sexual and emotional abuse have a lasting effect on children, both in memory and in their effect on mental health, with retrospective and prospective physical abuse and emotional abuse/neglect and prospective sexual abuse linked to increased risk for depression, anxiety and general psychological distress.

The decrease in prevalence of retrospectively reported ACEs, compared to those reported prospectively, may be a result of a life view composed over time and filtered through recent stressors. Stressful life events are thought to negatively impact multiple areas of psychosocial functioning in general [209]. This study finds that there is an association between the number of recent stressors reported and the number of prospectively and retrospectively reported ACEs, that these reports of ACEs will be associated with poor mental health; but also that these associations are not straightforward. Young adults who prospectively report four or more ACEs, and those who retrospectively report any number of ACEs, with the strongest effect on four or more, are more likely to report a greater number of recent stressors. This effect of recent stressors has been assessed previously. One study found that stressful live events were associated with higher alcohol consumption among women exposed to childhood maltreatment, but could not find evidence for the role of recent events in the alcohol consumption of women not exposed to maltreatment [210]. Adversity experienced in childhood may sensitize individuals to future negative events, aggravating negative outcomes, which could explain the link between retrospective reporting, recent stressors and poorer later life outcomes. This finding may support a stress-sensitization hypothesis that early adversity leads to psychobiological changes that heighten sensitivity to subsequent stressors, altering strategies for coping with stress [211] and vulnerability to negative outcomes [33, 212, 213]. Harkness and colleagues assessed the relationship between childhood abuse and neglect and stressful life events for adolescents with depression and proposed that maltreatment may be an important risk factor that sensitizes individuals to the effects of acute independent life events [214]. Similar results were found in a psychiatric sample of adolescents; the timing and number of negative life events increased the

risk of emotional and behavioral disorders by 3-6 times [215]. Honkalampi and colleagues suggest that ACEs may predispose individuals to depression, but current stressful events actualize these symptoms [216]. Recent stressors seem to reinforce a stress accumulation model — whereby early life stressors and subsequent stressors have unique and additive contributions [217, 218]; supporting the idea that a number of mechanisms may work to link ACEs differentially to outcomes, whether psychological, physiological or behavioural. We propose that recent stressors have a confounding effort on the relationship between reports of ACEs and mental health outcomes; directly impacting mental health and possibly influencing autobiographical memory involved in retrospective recall. Further research should focus on the trajectories and pathways of groups of individuals who report prospective and retrospective ACEs and recent stressors.

While this study's findings show that males and females generally report similar numbers of ACEs prospectively, and males report significantly more ACEs retrospectively, females are up to twice as likely to suffer psychological distress as a result of these experiences. Stress-related disorders such as anxiety and depression are disproportionately prevalent in women. Literature suggests that stress and gonadal hormones may interact to predispose women to depression and anxiety [88]; adding further complexity in the form of sex to the relationship between ACEs, recent stressors and mental health. Mental health assessments that capture externalized emotions and behaviour such as conduct disorder and aggression may better explain how adversity in childhood affects the mental health of young men.

Further research is required to tease out the mechanisms by which ACEs affect mental health using both subjective and objective, and prospective and retrospective reports. The continually contentious challenges around retrospective recall are somewhat allayed with emerging evidence of their links to both subjectively and objectively assessed negative outcomes. However, research cautions that psychopathology prior to or at the time of recall may bias memory towards either recalling a greater number of negative events, an exaggeration of some memories or a focus on painful ones [84]. This may denote a circular relationship between mental health and retrospective recall of ACEs or as Hardt and Rutter infer, that mental health is the filtering out of negative memories or their reimagining as benign [84].

The authors acknowledge a number of limitations in the study. The first set relate to the ACEs measure and method of collection. Measurement error in retrospective designs can be caused by a number of factors, including memory lapse over time [219], cognitive functioning at the time of the event in question [151], the non-disclosure – whether voluntary or involuntary – of memories and specific details in the case of sensitive or traumatic experiences [219], and differential recall bias due to the participant's current life status and mood state at the time of reporting on past events [150]. Studies have cautioned on the sole use of retrospective accounts, particularly when assessing experiences prone to subjective judgment, but maintain that their usefulness in research cannot be negated and is enhanced when paired with additional sources, as in the current study [84, 193, 220]. With regard to the ACEs measure, the original ACEs inventory is limited in the type of adversities included which have been extended in this study and others, but room remains for further refinement of a more comprehensive set of ACEs. Additional limitations of ACE scores are that they do not distinguish between single episode, recurrent or chronic adversities and that the cumulative risk approach to scoring and summing of individual ACEs considers each as equivalent to the next. As a trade-off, the cumulative ACE score enables more precise and quantifiable examination and a number of studies have demonstrated a strong dose-response relationship between the ACE score and later life health and well-being outcomes [16, 60, 221].

The second set of limitations to this study relate to the data within Bt30. At the 22-year data collection wave, and similar to all birth cohort studies, Bt30 had an attrition rate of 50% due to a range of factors, including local migration patterns, which have been explored and described elsewhere [102, 109]. Previous analysis on the same 22-year data on ACEs found no significant differences by sex and SES, the two covariates used in this study, between the participants surveyed and those not surveyed at the 22-year wave [65]. The authors make no claims about the generalizability of the results to the South African population but maintain that the initial cohort size (3,273) was large enough at the start to mitigate the effects of attrition on internal validity.

4.5. Conclusion

In conclusion, this study finds the number, type and time of recall of ACEs have differential impacts on mental health in early adulthood. Both prospective and retrospective reports of ACEs are linked to psychological distress, with a stronger association between retrospective reports,

and recent stressors reinforcing this relationship. Females are twice as likely to report poor mental health outcomes albeit reporting similar or fewer ACEs but the mental health assessment used in the study may not be capturing expressions of psychological distress in young males. The overall findings suggest that retrospective reports of ACEs can effectively screen for psychological distress in early adulthood and that the presence of recent stressors will be an exacerbating factor.

CHAPTER 5: THE IMPACT OF ACEs ON HEALTH AND HUMAN CAPITAL

The long-term health and human capital consequences of adverse childhood experiences in the Birth to Thirty cohort: single, cumulative and clustered adversity

5.1. Introduction

Human capital is collectively the knowledge, skills and health inputs accumulated across the lifespan that enables individuals to realize their full potential and contribute to the economic productivity of a society. It is manifest through a range of constructs, including educational attainment, physical and mental health, and social outcomes. It is well documented that human capital trajectories vary greatly within communities [222], and that one's early experiences account for a substantial portion of the variation in adult human capital outcomes [223-225]. Another construct linked to economic productivity is ACEs which is related to poorer health and social outcomes – or human capital – across the life course [21, 25, 226]. Early adversity in general, including child maltreatment, has long been established as detrimental for health and wellbeing [227, 228]. Furthermore, the concept of ACEs—a quantifiable index of exposure to a range of adverse experiences, has in recent years been linked to a range of negative outcomes. The original ACE study found significant associations between ACEs and risk for alcoholism, drug abuse, smoking, risky sexual behaviour, obesity, depression, suicide attempt, heart disease, cancer, chronic lung disease, liver disease, and skeletal fractures [19]. Following this seminal study, publications linking ACEs to one or more outcome grew exponentially [10] and systematic reviews and meta-analyses provided valuable overviews. One meta-analysis reviewed 37 studies and described links between greater exposure to ACEs and physical inactivity, overweight, obesity, diabetes, smoking, heavy alcohol use, sexual risk behaviour, cancer, heart disease, respiratory disease, and mental ill health [25]. A second meta-analysis assessed 96 studies in which ACEs were examined against health and wellbeing outcomes. The study's findings mirrored those of the previous meta-analysis, linking ACEs to a range of psychosocial, behavioural, and physical health outcomes [21]. Finally, a third meta-analysis on studies from Europe and North America not only connected ACEs to risk factors for ill health, but estimated the associated annual financial costs attributable to ACEs to be $581 billion in Europe and $748 billion in North America [67]. Identifying the specific ACEs or combinations of ACEs which are strongly linked to adult human capital outcomes may help elucidate the mechanisms of these

associations and aid in developing target interventions to reduce the risk of poor human capital outcomes.

However, the measurement of ACEs has important limitations; studies typically rely on cumulative risk scores [229] or individual adversities measured through retrospective self-reports [164]. Evidence describes the relationship between ACEs and social and health problems as one that predicts the risk to increase in a strong and graded manner as the number and severity of ACEs increase [16, 230]. Hence, a single adversity approach ignores the high probability that adversities co-occur and have an exponential impact. On the other hand, cumulative risk scores assume equal weighting of adversities while a number of studies have shown specific ACEs to be more deleterious that others [231-233]. Although there are currently no guidelines on the ACEs scoring in the available literature some studies point to the 'four or more' cut-off functioning as a threshold level, with noticeable deviations in a range of outcomes at that mark [25]. As an alternative to both of these approaches, analyses of the patterning of ACEs recognizes that the clustering and qualitative differences in combinations of ACEs are important for health and social outcomes and are linked to different consequences [18, 234].

Another important limitation in ACEs research is the reliance on retrospective reports [21]. Previous research in longitudinal birth cohorts has demonstrated that prospective and retrospective reports of ACEs show poor agreement [179, 235], similar to findings in this cohort [193], and are differentially linked to outcomes [179, 231]. Meta-analysis findings conclude that prospective and retrospective measures of ACEs largely identify two different sets of individuals, cautioning that the measures should not be used interchangeably to study pathways of risk and outcomes. It is therefore important to compare findings based on prospective and retrospective measures in the same individuals.

Conceptually, frameworks such as the ACEs Pyramid—emanating from the ACEs study—attempt to explain the ways in which early adversity disrupts biological and psychological processes through interactions between genes and the environment [25]. The bio-developmental framework posits that early adversity precedes physiological maladaptations and disruptions due to either cumulative exposure or biological embedding during sensitive periods, leading to a range of poor health and wellbeing outcomes [26]. The ACEs Pyramid follows this logic but recognizes that exposure to ACEs is somewhat predetermined by social conditions and historical

trauma in societies. ACEs then go on to disrupt neurodevelopment, giving rise to socio-emotional and cognitive impairments linked to the adoption of health risk behaviours that increase vulnerability to disease, disability, and social problems [10].

The objectives of this study are therefore to a) examine the associations between ACEs and adult human capital, and b) explore how the measurement of ACEs may vary in relation to these human capital outcomes. Prior research, including this cohort, has highlighted sex differences in the prevalence of ACEs and their associations with outcomes [61, 193, 231, 236-238]. The patterning of ACEs and their links to human capital outcomes will be disaggregated by sex throughout this analysis. To our knowledge, no study to date has investigated the relationship between ACEs and adult human capital outcomes, using these unique measurement methods, in LMICs.

5.2. Materials and methods

5.2.1. Study design and participants

The Birth to Thirty study (Bt30, previously known as Birth to Twenty Plus) is a South African birth cohort of all singleton children born to mothers who were residents of Soweto-Johannesburg in a 7-week period of enrolment in 1990 [102]. The study is the largest and longest running birth cohort on the African continent, with an initial recruitment of 3273 participants, including their primary caregivers and subsequently a third generation born to the original cohort. The study has routinely followed participants through 21 data collection points over its 30-year lifespan, assessing growth, health, education and wellbeing domains. Detailed descriptions of the cohort methods and sample have been published elsewhere [102-104, 239]. For this study, data on 1436 participants included in the last data collection wave at age 28 were used. Ethics clearance was obtained from the Witwatersrand University Committee for Research on Human Subjects and written consent was obtained from all participants.

5.2.2. Exposures

ACEs in this study are defined as physical abuse, sexual abuse, emotional abuse or neglect; household dysfunction in the form of experience of divorce or parental separation, child separation, exposure to intimate partner violence (IPV), experience of living with a chronically ill or disabled individual or an individual with substance abuse problems, parental death, household legal trouble, and chronic household unemployment (Appendix 1). Retrospective

reports of individual ACEs were created from a single report in the 22-year data collection wave. Prospective reports of individual ACEs were composed across the first 18 years of available data from caregiver reports (children aged 0-7-years-old) and self-reported by the Bt30 participant thereafter.

5.2.3. Outcomes

Human capital outcomes were measured at age 28 and include both health and social measures conceptualized in a previous study [223].

5.2.3.1. Education and employment

Education refers to incomplete secondary schooling. Participants reported their highest school grade attained, dichotomized into complete (coded 0) or incomplete (1) secondary education. For the employment outcome, participations reported whether they were formally employed (i.e., had a work contract), (coded 0) vs. not formally employed (1).

5.2.3.2. Welfare receipt

Welfare receipt refers to a government cash transfer available to primary caregivers of children who qualify through an income means test. Welfare receipt in the form of a Child Support Grant (yes, coded 1, vs no, 0) was recorded from data supplied by the South African Social Security Agency. Participants consented to the linking of this data through identity numbers.

5.2.3.3. Mental health

Mental health was conceptualized as psychological distress and assessed using the WHO's Self Reporting Questionnaire, which includes 20 binary items assessing symptoms experienced during the past month, such as "Do you feel nervous, tense or worried?", "Do you sleep badly?", and summed to obtain a total psychological distress score (alpha=0.93). Participants in the top 20% of symptoms score were considered as having high psychological distress. This decision was made based on the distribution of symptoms amongst the sample and the intention to isolate those with the most severe mental health challenges.

5.2.3.4. Social isolation

Social isolation was assessed using 8 items based on the Inventory of Socially Supportive Behaviors, such as "how often you had someone who would listen to you when you needed to talk", "had someone you trust to talk with about your problems". Items were answered on a 5-

point scale from never to always, and summed. Scores were dichotomized to identify participants who reported high levels of social isolation (scoring at the bottom decile of the distribution, coded 1) vs those reporting lower levels (0).

5.2.3.5. Substance abuse and criminality

Substance abuse was derived from either reporting alcohol use more than 2-3 times a week and/or current use of non-medical drugs (including marijuana), scored as yes (1) or no (0). Again, isolating the sample with the greatest severity of substance use. Criminality was assessed by asking participants whether, in the last year, they had been arrested, detained, jailed, or committed a crime without being caught, for example, stolen a car/motorbike, stolen in a shop or from a person, sold drugs or stolen goods, set property on fire or damaged/destroyed property, assaulted someone or forced someone to have sex. A positive answer to any of the questions was coded 1 vs 0.

5.2.3.6. HIV infection

HIV status was assessed by asking "Have you ever tested positive for HIV?", coded 1 if yes and 0 if no.

5.2.4. Covariates

Covariates were included in this study based on their significance in the literature to multiple health and wellbeing outcomes [240, 241], including in prior work on this cohort [223, 231]. The covariates include sex; socio-economic status at participant birth, age 12, and age 22, measured as wealth quintiles derived from a list of assets (e.g., TV, fridge, car, phone); maternal age at birth sorted into four age categories based on the distribution of maternal age (15-18, 19-24, 25-34, 35-46), and continuous measures of maternal and paternal years of schooling.

5.3. Statistical Analysis

Single ACEs were included in the analyses as individual binary variables. Each ACE was coded '0' for a negative response and '1' for a positive response. To measure the effects of cumulative adversity, the individual binary ACEs were transformed into a categorical score with 5 levels for each participant as follows: 0 = 'no reported ACEs', 1 = 'one reported ACE', 2 = 'two reported ACEs', 3 = 'three reported ACEs' and 4+ = 'four or more' reported ACEs; following convention in the literature and allowing for comparability with other studies. The Bt30 sample has limited

variability in their SES, similar low variability in the distribution of ACEs, and high prevalence of ACEs, given that the site of the study (i.e. Soweto-Johannesburg) is a previously socio-economically disadvantaged and low-income area. Most studies assessing either prospective or retrospective ACEs are based in high-income countries and often with populations with more heterogeneity in the distribution of ACEs [235]. To maximize within-cell counts and meaningfully analyse the data, cumulative ACEs were also categorized in a binary fashion as '0' = 'less than six and '1' = 'six or more' reported ACEs. The 'six or more ACEs' cut-off was preferred over the conventional cut-off of '4 or more ACEs' as this represents the mean ACE score for the Bt30 sample and takes into account the higher prevalence of ACEs in the sample.

Clusters of ACEs were derived using latent class analysis (LCA), a mixture model technique that identifies groups of individuals (i.e., latent classes) on the bases of similarities in their pattern of co-occurrence of ACEs exposure. LCA was separately applied to the prospective and the retrospective reports. Several models were estimated with 2 to 6 latent classes, and compared using the Bayesian Information Criteria (BIC; used as primary index), Akaike's Information Criteria (AIC), and sample-size adjusted BIC (SSABIC). Lower values of the BIC, AIC, and SSABIC indicate a better fitting model. Entropy was also used to assess the distinction between classes, where values closer to 1 indicate good distinction (Appendix 9, Table 5A). Once the best model was identified, participants were assigned to their most likely class, creating a categorical cluster variable. LCA was performed with Mplus version 8, with missing data on ACEs variables handled using Full Information Maximum Likelihood.

Associations between the three methods of measuring ACEs – single, cumulative, and clustered – and human capital outcomes were examined using logistic regression. Two sets of models were fitted for each ACE measurement for both retrospective and prospective reports of ACEs: (i) a crude, unadjusted model (Appendix 9, Tables 5B and 5C), followed by (ii) models adjusted for all covariates (Appendix 9, Tables 5D and 5E). Sex was included as a covariate in all models but separate analyses by sex, excluding the variable at the covariate level, was conducted and is available in Appendix 9, Tables 5F and 5G. To handle missing data on the covariates, we used multiple imputation by chained equations, so that models were estimated across 10 datasets and then pooled. All data management, multiple imputation, and regression analyses were conducted

in Stata version 15.1. Data missingness for each of the ACEs, covariates, and outcomes is detailed in Table 13.

Table 13: Description of the study sample (n=1436)

Variable	Male	Female	Total	Missing
Exposures				
Single Prospective ACEs				
Physical abuse	400 (58.57)	381 (50.73)	781 (54.65)	2 (0.14)
Sexual abuse	267 (39.09)	278 (37.17)	545 (38.13)	5 (0.35)
Emotional abuse	245 (35.98)	265 (35.43)	510 (35.71)	7 (0.49)
Child separation	92 (14.00)	120 (16.28)	212 (15.14)	42 (2.92)
Parental divorce	332 (49.63)	392 (52.55)	724 (51.09)	21 (1.46)
Parental death	160 (23.74)	152 (20.27)	312 (22.01)	12 (0.84)
Household death	416 (64.63)	463 (61.49)	879 (63.06)	8 (0.56)
Household substance abuse	305 (46.42)	355 (48.30)	660 (47.36)	44 (3.06)
Household illness/disability	413 (62.86)	460 (62.42)	873 (62.64)	42 (2.92)
Household legal trouble	292 (43.20)	228 (30.32)	520 (36.76)	8 (0.56)
Chronic unemployment	567 (86.30)	634 (86.02)	1,201 (86.16)	42 (2.92)
Exposure to IPV	372 (54.55)	285 (37.95)	657 (46.25)	3 (0.21)
Exposure to violence	530 (77.71)	474 (63.03)	1,004 (70.37)	2 (0.14)
Prospective ACE category				0 (0.0)
0 ACEs	3 (0.44)	5 (0.66)	8 (0.55)	
1 ACE	12 (1.76)	14 (1.86)	26 (1.81)	
2 ACEs	13 (1.90)	30 (3.98)	43 (2.94)	
3 ACEs	49 (7.17)	62 (8.23)	111 (7.70)	
4+ ACEs	606 (88.73)	642 (85.26)	1,248 (86.99)	
Prospective Binary ACE score				0 (0.0)
Less than 6 ACEs	348 (50.95)	442 (58.70)	790 (55.01)	
6 or more ACEs	335 (49.05)	311 (42.30)	646 (44.99)	
Prospective LCA derived ACEs				0 (0.0)
Class 1: Low adversity	43 (6.30)	70 (9.30)	113 (7.87)	
Class 2: Moderate adversity-dysfunction	223 (32.65)	350 (46.48)	573 (39.90)	
Class 3: Moderate adversity-abuse	127 (18.59)	106 (14.08)	233 (16.23)	
Class 4: High adversity	290 (42.46)	227 (30.15)	517 (36.00)	
Single Retrospective ACEs				
Physical abuse	58 (8.90)	41 (5.75)	99 (7.33)	71 (4.94)
Sexual abuse	16 (2.47)	36 (5.05)	52 (3.76)	74 (5.15)

Variable	Male	Female	Total	Missing
Emotional abuse	251 (37.19)	241 (32.44)	492 (34.82)	18 (1.25)
Parental divorce	251 (43.35)	276 (44.44)	527 (43.90)	236 (16.43)
Parental death	184 (27.34)	167 (22.57)	351 (24.96)	23 (1.60)
Household death	191 (33.39)	199 (32.20)	390 (32.80)	246 (17.13)
Household substance abuse	205 (30.37)	178 (23.96)	383 (27.17)	18 (1.25)
Household illness/disability	240 (35.50)	277 (37.48)	517 (36.49)	21 (1.46)
Household legal trouble	172 (25.48)	144 (19.38)	316 (22.43)	18 (1.25)
Chronic unemployment	306 (45.33)	296 (39.84)	602 (42.59)	18 (1.25)
Exposure to IPV	81 (12.05)	97 (13.18)	178 (12.62)	28 (1.95)
Exposure to violence	222 (33.04)	160 (21.83)	382 (27.44)	31 (2.16)
Retrospective ACE category				
0 ACEs	58 (8.49)	76 (10.09)	134 (9.29)	
1 ACE	117 (17.13)	135 (17.93)	252 (17.53)	
2 ACEs	98 (14.35)	168 (22.31)	266 (18.33)	
3 ACEs	126 (18.45)	127 (16.87)	253 (17.66)	
4+ ACEs	284 (41.58)	247 (32.80)	531 (37.19)	
Retrospective Binary ACE score				0 (0.0)
Less than 6 ACEs	582 (85.21)	677 (89.91)	1,259 (87.67)	
6 or more ACEs	101 (14.79)	76 (10.09)	177 (12.33)	
Retrospective LCA derived ACES				0 (0.0)
Class 1: Low adversity	268 (39.24)	332 (44.09)	600 (41.78)	
Class 2: Moderate adversity-dysfunction	184 (26.94)	203 (16.96)	387 (26.95)	
Class 3: Moderate adversity-abuse	109 (15.96)	125 (16.60)	234 (16.30)	
Class 4: High adversity	122 (17.86)	93 (12.35)	215 (14.97)	
Outcomes				
Psychological distress	58 (10.86)	143 (23.68)	201 (17.27)	298 (20.75)
Social isolation	73 (13.67)	45 (7.45)	118 (10.56)	298 (20.75)
Incomplete secondary education	207 (39.06)	152 (25.33)	359 (32.20)	306 (21.31)
Unemployed	242 (45.32)	254 (42.12)	496 (43.72)	299 (20.82)
Welfare receipt[1]	5 (1.28)	246 (51.36)	251 (28.82)	565 (39.35)
Criminality	150 (28.04)	32 (5.30)	182 (16.67)	297 (20.68)
Substance use	210 (41.02)	73 (12.74)	283 (26.88)	351 (24.44)
HIV infection	52 (11.13)	96 (16.78)	148 (13.96)	397 (27.65)
Covariates				
Sex	683 (47.56)	753 (52.44)	1,436 (100.00)	0 (0.0)
Socio-economic status at birth				115 (8.01)
Quintile 1	101 (16.19)	103 (14.78)	204 (15.49)	

Variable	Male	Female	Total	Missing
Quintile 2	112 (17.95)	126 (18.08)	238 (18.02)	
Quintile 3	214 (34.29)	240 (34.43)	454 (34.36)	
Quintile 4	135 (21.63)	139 (19.94)	274 (20.79)	
Quintile 5	62 (9.94)	89 (12.77)	151 (11.36)	
Socio-economic status at 12 years				380 (26.46)
Quintile 1	114 (23.12)	123 (21.85)	237 (22.49)	
Quintile 2	164 (33.27)	169 (30.02)	333 (31.65)	
Quintile 3	72 (14.60)	88 (15.63)	160 (15.12)	
Quintile 4	54 (10.95)	71 (12.61)	125 (11.78)	
Quintile 5	89 (18.05)	112 (19.89)	201 (18.97)	
Socio-economic status at 22 years				39 (2.72)
Quintile 1	209 (31.48)	230 (31.38)	439 (31.43)	
Quintile 2	106 (15.96)	116 (15.83)	222 (15.90)	
Quintile 3	154 (23.19)	139 (18.96)	293 (21.08)	
Quintile 4	109 (16.42)	139 (18.96)	248 (17.69)	
Quintile 5	86 (12.95)	109 (14.87)	195 (13.91)	
Maternal age at birth of child				2 (0.14)
15-18 years	72 (10.54)	89 (11.85)	161 (11.20)	
19-24 years	233 (34.11)	254 (33.82)	487 (33.97)	
25-34 years	305 (44.66)	331 (44.07)	636 (44.37)	
35-46 years	73 (10.69)	77 (10.25)	150 (10.47)	
Maternal education, mean (SD)	9.57 (2.63)	9.71 (2.60)	9.64 (2.62)	106 (7.38)
Paternal education, mean (SD)	10.49 (2.43)	10.62 (2.47)	10.56 (2.43)	426 (29.67)

[1]Welfare receipt calculated for the sub-sample who have children (n=871)

5.4. Results

5.4.1. Characteristics of the sample

Among the 1436 participants in the study, 47.5% were male and 52.4% were female (

Table **13**). Similar proportions of participants were born to young mothers (11.2% to mothers aged 15-18 at birth and 10.4% to mothers aged 35-44+ at birth), with the majority (78.3%) born to mothers aged between 19-34. Fathers had on average 1 year of additional schooling (mean=10.5) than mothers (mean=9.5). At birth, 15.4% of participants were in the lowest wealth quintile compared to 11.4% in the highest, at 12-years-old 22.4% were in the lowest quintile and 19.0% in the highest, and at age 22, 31.4% fell into the lowest quintile and 13.9% in the highest;

leaving a shrinking middle across quintile 2-4 from birth to age 22 of 73.1%, 58.5%, and 54.6% respectively.

5.4.2. Prevalence of human capital outcomes

The most prevalent adverse outcomes were unemployment (43.7%), incomplete secondary education (32.3%), substance use (26.9%), and welfare receipt (28.2%). Just over half of the females with children (51.4%) receive welfare compared to 1.3% of males caring for children. While both parents are eligible to receive welfare in the form of the Child Support Grant in South Africa, the greatest number of recipients (over 95% nationally and 98% in this sample), are women [242]. Females reported higher rates of psychological distress (23.7% compared to 10.9%), and HIV infection (16.8% compared to 11.1%) than males. Males reported higher rates of social isolation (13.7% compared to 7.5%), incomplete secondary education (39.1% compared to 25.3%), criminality (28.0% compared to 5.3%), and substance use (41.0% compared to 12.7%) compared to females.

5.4.3. Prevalence of ACEs

5.4.3.1. Single ACEs

The most commonly reported prospective ACEs were chronic unemployment (86.2%), exposure to violence (70.4%), household death (63.1%), and household illness or disability (62.6%). Prospectively, 54.7% of participants reported physical abuse, 38.1% reported sexual abuse and 35.7% reported emotional abuse. Reported exposure to all single ACEs, with the exception of parental death, decreased in retrospective reports. The most common retrospective ACEs were parental divorce (43.9%), chronic unemployment (42.6%), and household illness or disability (36.5%). Retrospectively, physical abuse was reported at a rate of 7.3%, sexual abuse at 3.8% and emotional abuse or neglect at 34.8%.

5.4.3.2. Cumulative ACEs

Similar patterns are seen in the prevalence of cumulative ACEs. While 87.0% of participants report 4 or more ACEs prospectively, 37.2% report 4 or more ACEs retrospectively. The proportion of participants reporting no ACEs remains low both prospectively (0.6%) and retrospectively (9.3%). Using the binary cut-off, 55.0% of participants report less than 6 ACEs prospectively and 87.7% report less than 6 ACEs retrospectively.

5.4.3.3. Clustered ACEs

The best fitting LCA models identified 4 classes for both the prospective and retrospective ACEs: low adversity (7.9% prospective, 41.8% retrospective); moderate adversity-dysfunction (39.9% prospective, 27.0% retrospective); moderate adversity-abuse (16.2% prospective, 16.3% retrospective); and high-adversity (36.0% prospective, 15.0% retrospective).

Figure 27 shows the predicted probability of each adversity for each of the prospective and retrospective classes that led to the characterization of the classes. For prospective ACEs, low adversity was the smallest class with the highest probabilities being a 28% chance of living in a household in which a member has died and 23% chance of living in a household where a member has a serious chronic illness or disability. Inclusion in the moderate adversity-dysfunction class was driven by ACEs related to household dysfunction, namely high chances of chronic unemployment (88%), parent divorce (47%), household death (63%), and household substance abuse (43%), among others. Participants in moderate adversity-abuse had a 66% chance of reporting physical abuse, 46% chance of reporting emotional abuse, as well as high levels of chronic unemployment (69% chance), exposure to IPV (83%), and community violence (94%). In the high adversity class, the probability of experiencing any one of the ACEs was greater than 40% for 11 of the 13 ACEs.

For retrospective clusters of ACEs, the low adversity group was characterized by highest probabilities for parental divorce and household death (31% each). Participants in the moderate adversity-dysfunction class had a 26% chance of reporting emotional abuse compared to participants in moderate adversity-abuse with a 66% chance of reporting emotional abuse. While those participants in moderate adversity-abuse were very unlikely to report chronic unemployment and household legal trouble compared to participants in moderate adversity-dysfunction who were almost certainly experiencing those two ACEs. The high adversity class had a more than 40% chance of reporting 7 of the 12 ACEs, with 81% chance of emotional abuse, 73% chance of household illness/disability, 64% chance of household substance abuse,

60% chance of parent divorce, and were more likely to report chronic unemployment (100%) and household legal trouble (100%).

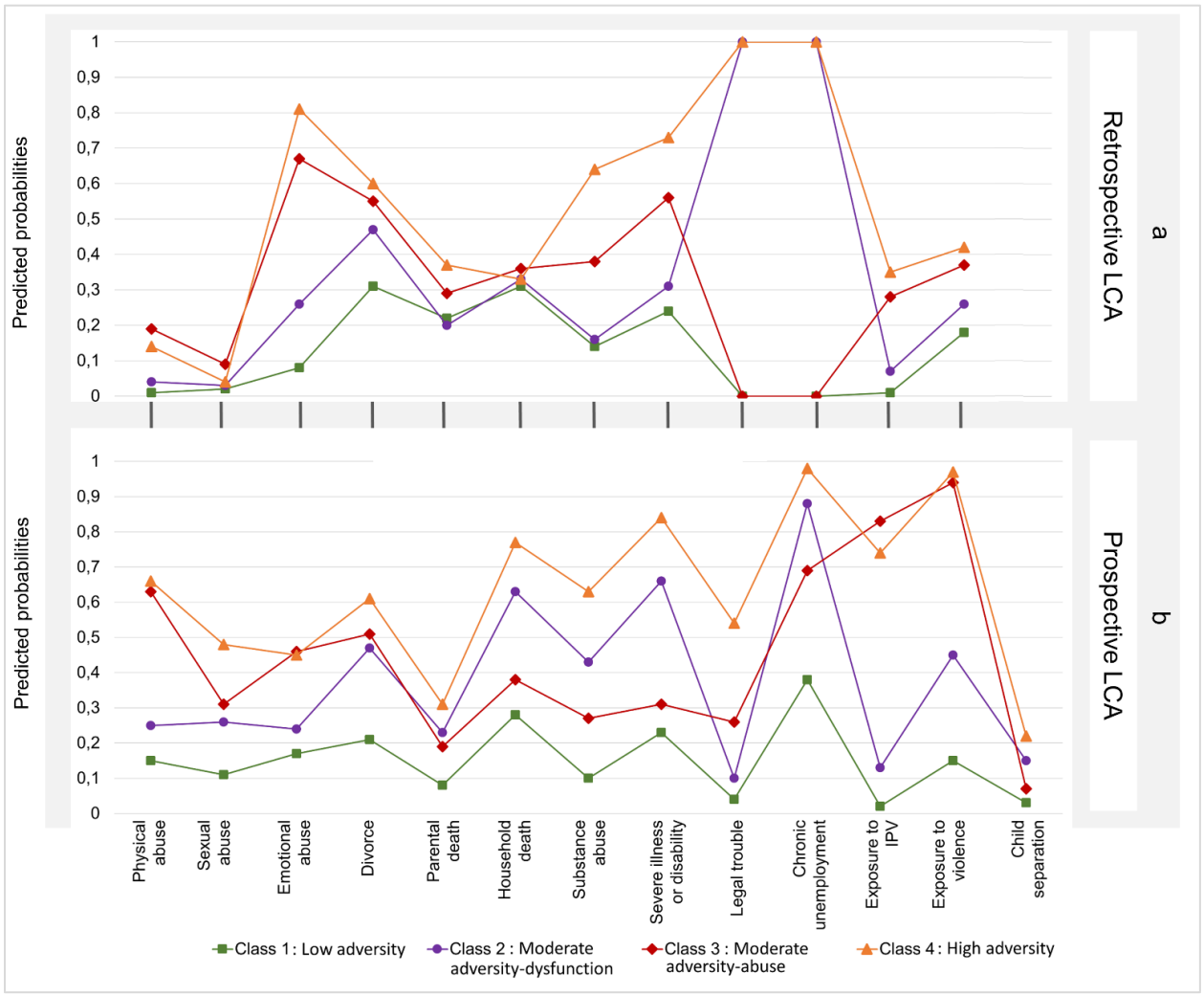


Figure 27: Predicted probabilities for latent class analyses of: (a) retrospective ACEs; (b) prospective ACEs

5.4.4. Associations between ACEs and human capital outcomes

Figure 28 illustrates the significant findings from adjusted logistic regressions displayed for the associations between both prospective and retrospective single ACEs and human capital outcomes for the total sample, as well as disaggregated by sex. Figure 29 shows the significant adjusted associations between prospective and retrospective cumulative and clustered ACEs and human capital outcomes, again for the total sample and disaggregated by sex.

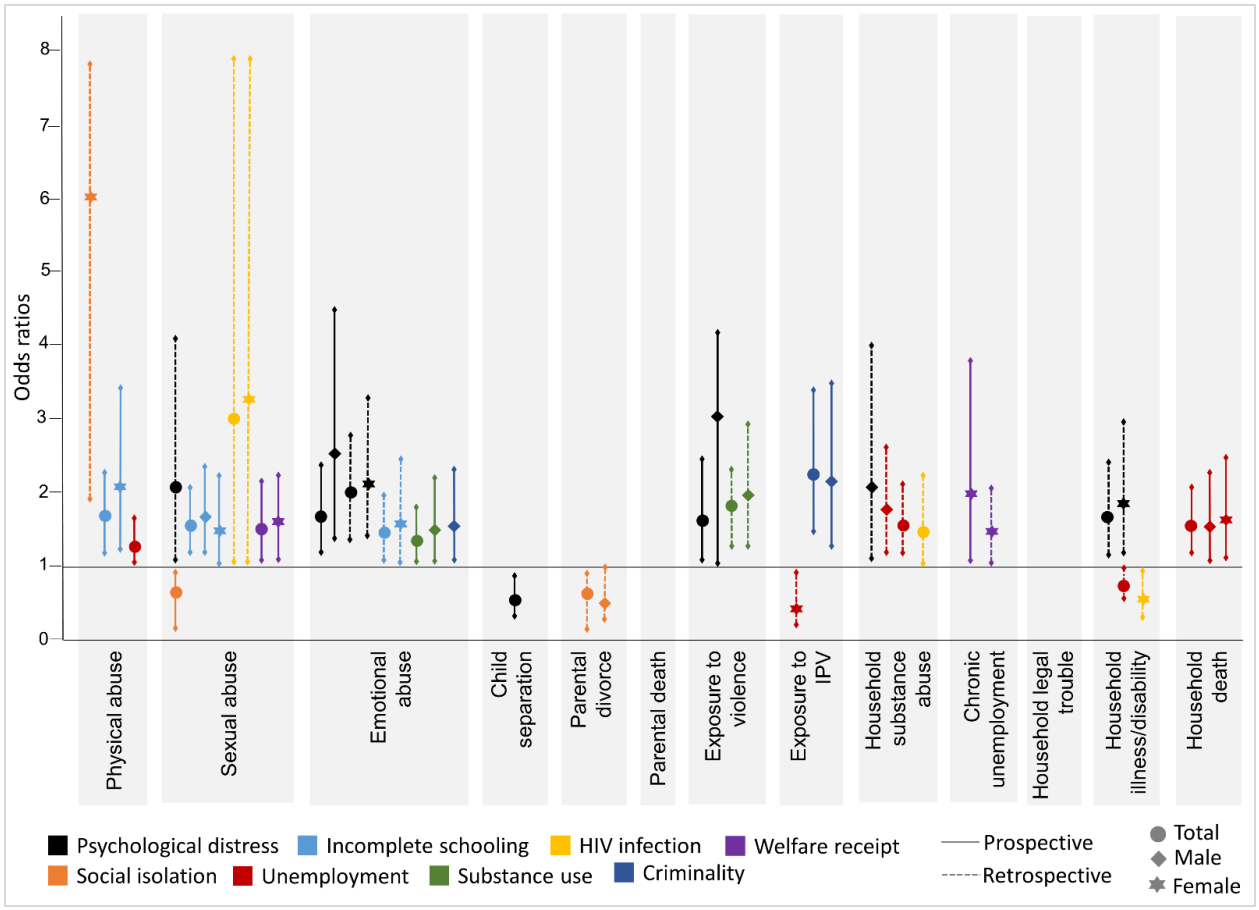


Figure 28: Significant adjusted associations (odds ratios) between single ACEs and human capital outcomes, for the total sample and disaggregated by sex

5.4.4.1. Single adversities and human capital outcomes

Prospective physical abuse was associated with greater likelihood of incomplete schooling (OR 1.69, CI 1.21-2.35) and unemployment (OR 1.31, CI 1.02-1.69) in the full sample. Females who reported prospective physical abuse had a greater likelihood of incomplete schooling (OR 2.08, CI 1.25-3.45) than their male counterparts (OR 1.69, CI 0.96-2.21) and females who reported retrospective physical abuse were 6.02 times (CI 1.93-8.85) more likely than males (OR 0.96, CI 0.33-2.74) to experience social isolation. Prospective sexual abuse was associated with welfare receipt (OR 1.53, CI 1.07-2.20) and incomplete schooling (OR 1.58, CI 1.21-2.08), and retrospective sexual abuse was associated with psychological distress (OR 2.05, CI 1.02-4.12) and HIV infection (OR 3.03, CI 1.03-8.91) in the full sample. Prospective emotional abuse was associated with greater odds of experiencing psychological distress (2.54 (CI 1.42-4.53) and substance use (1.52 (CI 1.01-2.25) for males only; while retrospective emotional abuse was associated with psychological distress (OR 2.15, CI 1.39-3.32) and incomplete schooling (OR

1.60, CI 1.02-2.49) for females only. Males were also 1.57 (CI 1.04-2.38) times more likely to report criminality if they prospectively reported emotional abuse. Prospective exposure to violence was associated with psychological distress (OR 1.64, CI 1.08-2.49), and again the association is stronger for males (OR 3.05, CI 1.01-9.18) than females (OR 1.52, CI 0.97-2.39). Retrospective exposure to violence was linked to substance abuse in males (OR 1.96, CI 1.30-2.96). Participants exposed to IPV in the home prospectively had a 2.27 times (CI 1.49-3.45) greater likelihood of criminality and those who reported a death in the household were more likely to be unemployed (OR 1.57, CI 1.17-2.11). Males who reported substance abuse in the household retrospectively were 1.8 times (CI 1.21-2.66) more likely to be unemployed and 2.08 times (CI 1.09-3.99) more likely to experience psychological distress. Retrospective serious illness or disability in the household was associated with higher odds of psychological distress for females (OR 1.88, CI 1.18-2.98).

5.4.4.2. Cumulative ACEs and human capital outcomes

The risk for poorer outcomes increased along with the number of ACEs whether reported prospectively or retrospectively. Reporting more than 6 ACEs prospectively was significantly associated with greater odds of psychological distress (OR 1.63, CI 1.19-2.23), incomplete schooling (OR 1.51, CI 1.15-1.99), unemployment (OR 1.28, CI 1.10-1.64), and criminality (OR 1.80, CI 1.28-2.54) compared to reporting less than 6 ACEs in the full sample – all of which were only significant for males when disaggregated by sex (OR 1.97, CI 1.11-3.48; OR 1.74 CI 1.20-2.53; OR 1.47, CI 1.04-2.09; OR 1.84, CI 1.22-2.76, respectively). More than 6 ACEs retrospectively was associated with increased likelihood of psychological distress (OR 1.72, CI 1.13-1.32) and criminality (OR 1.69, CI 1.09-2.63) compared to less than 6 ACEs. Females retrospectively reporting 3 ACEs and 4 or more ACEs were 3.5 (CI 1.13-10.38) and 5.4 (CI 2.04-14.51) times more likely to report psychological distress, respectively. Females were 2.8 times (CI 1.18-6.5) more likely to engage in criminality if they experience more than 6 ACEs and males are more than 3 times more likely to engage in criminality when they report more than 1 ACE (OR 3.10, CI 1.05-9.14 for 2 ACEs; OR 3.97, CI 1.41-11.21 for 3 ACEs; and OR 3.64, CI 1.27-10.47 for 4+ ACEs).

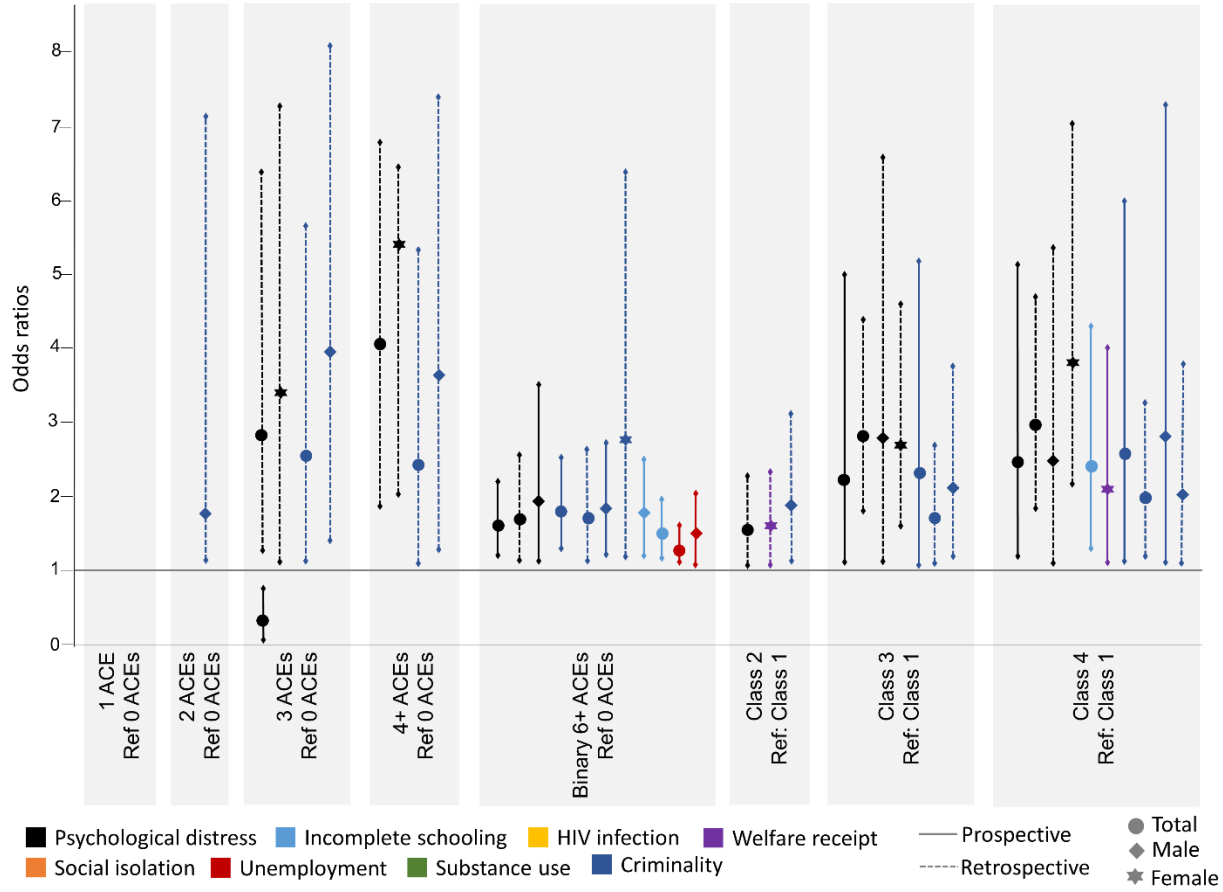


Figure 29: Significant adjusted associations (odds ratios) between cumulative and clustered ACEs and human capital outcomes, for the total sample and disaggregated by sex

5.4.4.3. Clustered ACEs and human capital outcomes

Prospectively, compared to the low adversity cluster, the odds of experiencing psychological distress in the moderate adversity-dysfunction cluster are 2.8 (1.18-6.64) for males and 2.71 (1.58-4.63) for females. Individuals in the moderate adversity-abuse cluster are 2.23 times (1.10-5.04) more likely to experience psychological distress and 2.29 times (1.01-5.22) more likely to engage in criminality. Females who fall in the moderate adversity-abuse cluster have a greater likelihood of welfare receipt (OR 1.60, CI 1.06-2.41). The high adversity cluster has greater odds of experiencing psychological distress (OR 2.47, CI 1.19-5.09), incomplete schooling (OR 2.39, CI 1.33-4.32), and criminality (OR 2.60, CI 1.12-6.02).

Retrospectively, when comparing all other clusters to the low adversity group, there is a greater likelihood of psychological distress; the association is strongest in the high adversity cluster (OR 2.97, CI 1.86-4.74), followed by the moderate adversity-abuse group (OR 2.82, CI 1.8-4.41), and lastly the moderate adversity-dysfunction cluster (OR 1.52, CI 1.01-2.29). The moderate

adversity-abuse group is also associated with criminality (OR 1.69, CI 1.04-2.73). Males in the high adversity cluster have increased odds for criminality (OR 2.84, CI 1.10-7.34) and females in the same group are more likely to be receiving welfare assistance (OR 2.11, CI 1.10-4.05).

5.5. Discussion

5.5.1. Adverse childhood experiences and human capital

This study aimed to examine the relationship between ACEs and adult human capital outcomes using unique and underutilized measurement methods of ACEs in comparison to these human capital outcomes. To our knowledge, no other study has drawn on this methodological approach in studying ACEs and none in the LMIC context of sub-Saharan Africa. This study found that ACEs can be linked to poor human capital outcomes in young adulthood in an urban South African sample. There are a number of individual adversities that are independently associated with human capital outcomes, particularly the abuse-level variables. For example, incomplete schooling is associated with physical, sexual and emotional abuse; social isolation is associated with physical abuse; and welfare receipt and HIV infection are associated with sexual abuse. The persistent and independent impact that these abuse-level experiences have on health and wellbeing are supported in previous analysis [231]. Individual household dysfunction adversities also play a role in poor human capital outcomes. Household substance abuse was linked to psychological distress and unemployment; exposure to violence was linked to psychological distress and substance use, and household death was linked to unemployment. The cumulative effects of adversity in childhood were also evident. Exposure to greater levels of ACEs, irrespective of their type, were linked to poorer outcomes. Similarly, the clustering of ACEs could be linked to negative human capital outcomes.

Globally, and particularly in LMICs like South Africa, psychological distress contributes substantially to the burden of disease [243]. The prevalence of psychological distress – characterized by depression, anxiety and somatic symptoms here – in this sample (17.3%) is lower than reported in a nationally representative South African survey (23.9%) [244], although the current study focused on participants expressing the highest levels of psychological distress. Experiences of sexual and emotional abuse, as well as exposure to violence, and substance abuse and severe illness/disability in the household as a child were risk factors for presenting with high psychological distress in adulthood. Individuals with more than 3 ACEs and in any cluster other

than the low adversity group were significantly more likely to experience psychological distress. A growing body of research, including in this cohort [231], have linked ACEs to mental illness in various forms; internalizing and externalizing problems [245], depressive and anxiety disorders [246, 247], and personality disorders [248, 249]. Some of the possible mechanisms from early adversity to mental ill health include the disruption of adaptive emotion regulation processes, alterations in the structure and function of key areas of the brain, and the developmental of maladaptive coping strategies [250].

Social isolation – or the objective lack of interaction with others [251], was significantly associated with reported physical abuse in childhood in this study. The implications of prolonged social isolation on mental and physical health in younger populations is still emerging, but evidence of resultant cognitive decline in middle-aged [252] and mortality in mixed-aged populations [253, 254] is available. As more and more research is conducted, driven by COVID-19-induced social isolation, the persistent and serious consequences of social isolation for health and wellbeing are being recognized [255].

The South African schooling system is divided into 4 phases with mandatory attendance in the first 3 quarters and an optional 4th phase that results in graduation out of the school system [256]. Despite high rates of enrolment in both primary and secondary schooling [257], the rates of incompletion for the latter are alarmingly high with between 50-60% of learners not completing their secondary schooling [258][46]. Rates of secondary school incompletion in the current sample are much lower (32.2%) than the national average (~50.0%), but follow the same trend of females more likely to complete than males [259].

The capacity to progress out of school, into tertiary education and/or employment is crucial for maximized human capital. Reports of physical abuse, sexual abuse and emotional abuse in childhood as well as experiencing 6 or more ACEs cumulatively and being placed in the high adversity cluster are significant predictors for incomplete schooling in this study. Similar findings are seen in another birth cohort: retrospective physical and sexual abuse were significantly associated with failing to achieve secondary school qualifications, but these associations lost significance after adjusting for social, parental and individual factors [260]. The pathway from abuse to educational attainment is partially through performance at school; with

learners reporting abuse and maltreatment likely to perform poorly on tests, repeat grades and encounter more problems with schoolwork [261, 262].

Inextricably linked to incomplete schooling is unemployment given that income poverty and inequality in South Africa are driven by inequalities in qualifications and skills [263]. South Africa has an average unemployment rate of 34.4%, with youth unemployment (15-24-year-olds) at 64.4% and young adult unemployment (25-34-year-olds) at 42.9% [264]. Young adults in this study have similar rates of unemployment at 43.7%; risk factors for which were physical abuse, household death, and household substance abuse, as well as reporting 6 or more ACEs. A cross-sectional study looking at retrospective ACEs found that adults with 4 or more ACEs were 2.3 times more likely to be unemployed compared to adults with no ACEs [265], and other studies have linked early adversity to unemployment in similar ways [266-268]. Associations between ACEs and human capital outcomes such as unemployment and incomplete schooling are difficult to tease out given the high youth unemployment rates and poorly ranked education system in South Africa [269]. There is likely interplay between exposure to ACEs and contextual and structural factors. For example, with a national dependency ratio of 52.7% and 70% (59% in 2003) of children living in households with at least one working adult [270] – a household death may have impact on household income, ability to attend school and subsequent employment. In fact, one study estimates that a 1 percentage point increase in school attendance is associated with an average decrease of 6 percentage points in the dependency ratio [271].

Sexual abuse in childhood is independently associated with welfare receipt in adulthood for females, as was inclusion in the moderate adversity-abuse and high adversity groups. General social protection measures in South Africa have made substantial contributions to poverty reduction [272], and the Child Support Grant in particular has had multiple benefits for vulnerable children and families [273-275]. Nevertheless, the receipt of the grant is a good indication that the household is income- and resource-poor [276].

HIV infection was also independently associated with sexual abuse in childhood for females. Prevalence of HIV positive status in the sample was 14% – mirroring the national population at 14% and below the 15-49-year-old age group at 20% [277]. A cross-sectional study among 2042 post-natal women in Harare, Zimbabwe found that 15% of the women tested positive, and that women who reported child sexual abuse were 3 times as likely to test positive for HIV [278].

The mechanisms for infection could operate directly – with infection occurring as a result of forced sex or rape; or indirectly through the weakening of psychological wellbeing and other protective factors that could lead to risky behaviours [279, 280]. A South African study found that physical, sexual and emotional abuse and neglect were associated with a range of HIV-risk behaviours [281].

Substance use in adulthood was associated with emotional abuse and exposure to violence in childhood, but only for males in the sample. Substance abuse has long been a global health challenge contributing to personal disability and mortality and economic burdens to society [282]. Studies in South Africa and worldwide have linked childhood trauma directly and indirectly, through mediation, to substance use in adulthood [199, 283], and a recent meta-analysis suggests that individuals with 4 or more ACEs were twice as likely to be current smokers or heavy drinkers and 6 times as likely to drink problematically than those with no ACEs [25]. Criminality was linked to emotional abuse and exposure to IPV in childhood, as was inclusion in the moderate adversity-abuse and high adversity clusters. Females were almost 3 times more likely to engage in criminality if they reported 6 or more ACEs whereas males were 3-4 times more likely with more than 1 ACE. A study on siblings demonstrated that the likelihood of committing a crime doubled with experiences of child abuse and neglect [284]. Compared to females, relatively low levels of adversity could be linked to criminality in males; however, our analyses did not differentiate between serious and petty, or violent and non-violent crime which may contribute to these differences. Findings in the literature are divergent, with some studies arguing for similar propensities for females and males to engage in serious, persistent and violent crime [285], a study where males were at greater risk of committing a violent offense [286], and another where females were more likely to be arrested for violence [287]. The co-occurrence of substance use and criminality is well documented [288, 289], and recent research has examined pathways showing that for moderate-to-high substance users, ACEs are linked to increased criminality [290]. These findings are interesting and may partly explain the sex differences in expressions of criminality.

5.5.2. Measuring ACEs

Comparing different approaches to ACEs measurement reveals several insights with regard to human capital outcomes. Individual ACEs, particularly prospective physical, sexual and

emotional abuse and exposure to violence can be linked to poorer outcomes; retrospectively, these single ACEs as well as household dysfunction indicators are associated with poorer outcomes. Part of this may be that children may not be fully aware of household dysfunction, its extent or severity, as it occurs prospectively and may piece together these reports in hindsight; or only those participants who experienced severe household dysfunction may be reporting so retrospectively. Another possibility is that prospective and retrospective measures of ACEs may be identifying different groups of individuals within a sample and those identified as having greater ACEs prospectively may have different pathways to poor outcomes than those identified as have greater ACEs retrospectively [235].

Cumulative measures of ACEs show graded relationships with gradual increases in risk for poor outcomes, demonstrating their ability to show the cumulative effect of ACEs. Clustered ACEs improve on these measures through their ability to make qualitative distinctions between ACEs that tend to co-occur. However, the usefulness of the ACE score as a rapid screening tool should not be ignored. Cut-offs for ACE categories should be made in consideration with the distribution of ACEs among the population, the conventional cut-off at 4 ACEs in the five-level ACEs categories does not appear to be adequate at distinguishing between those who are at a greater risk for poorer outcomes in high adversity settings. These five-level ACEs categories, popularized by the CDC-Kaiser ACE study [19], appear to be more indicative of poorer outcomes when ACEs are assessed retrospectively compared to prospectively.

5.5.3. Implications of Findings

Single ACEs at the individual level – physical, sexual and emotional abuse have persistent and long-term impacts on a range of human capital outcomes. Exposure to high levels of adversity accumulated over childhood can lead to equally poor outcomes in adulthood. Patterns of ACEs can differentially predict human capital outcomes – the two distinct patterns are low-high and dysfunction-abuse. Individuals who fall into a high adversity category, characterized by generalized adversity across a range of indicators, are prone to poorer human capital outcomes. Prospectively, individuals with high likelihood of abuse and the co-occurrence of household dysfunction in the form of IPV, chronic unemployment and exposure to violence, are linked to adverse mental health. Retrospectively, emotional abuse and some household dysfunction can be linked to poorer human capital outcomes even in the absence of poverty proxied by chronic

unemployment. Individual ACEs and a moderate amount of adversity may contribute to resilience and protect against certain poor human capital outcomes. Both individual and cumulative ACEs – the same type and number of ACEs – appear to affect males and females in different ways, leading to different outcomes, so disaggregation by sex is important. One study assessing gendered profiles of adversity concludes that there are separate and distinct patterns of childhood adversities, with females experiencing more complex and varied patterns [237].

5.5.4. Strengths and Limitations

The Bt30 sample is situated in a previously disadvantaged urban area in South Africa, limiting the generalizability of findings. The prevalence of ACEs, both prospectively and retrospectively, is considerably higher than global and meta-analytic estimates [25]. However, ACEs evidence in low-income, high violence settings with widespread adversity across the lifecourse is slowly emerging [68, 69, 233, 291] and highlighting important similarities and differences in the field. Bt30 is one of few cohorts in an LMIC that has reached young adulthood – the period in which human capital disparities are likely to emerge [292]. This cohort is also one of few that is able to provide both prospective and retrospective data on ACEs, especially in LMIC contexts; comparisons between prospective and retrospective reports of ACEs are key to understanding the risk mechanisms that underlie poor outcomes. This is particularly true given limitations around self-reported retrospective data which can be open to social desirability bias, recall error and the like. The authors concede that the retrospective self-reports of ACEs may be exposed to such bias but counter that (a) self-reports may be closer to true estimates, taking into account unreported and unobserved adversity [293], and (b) that both self-reported retrospective and prospective measures of adversity show substantial links to poor outcomes [194], supporting the usefulness of these self-reported retrospective accounts of adversity.

5.6. Conclusions

The measurement of ACEs is more complicated than often assumed, both timing – prospective and retrospective reports – and the approaches of measuring ACEs can give differing insights into their links to adverse outcomes and thought needs to be given to how ACEs are used in practice and policy. Given South Africa's strained economy, it is critical that efforts are made to cultivate and protect human capital. The prevention of abuse in childhood – physical, sexual and emotional abuse – must be a priority. Families need to be supported to mitigate the effects of

household dysfunction. Evans & Kim suggest that “cumulative rather than singular exposure to a confluence of psychosocial and physical environmental risk factors is a potentially critical aspect of the environment of childhood poverty” (p. 77) [294]. For resource poor countries, understanding the potential impact of early adversity across the life course is critical to breaking the intergenerational cycle of poverty.

CHAPTER 6: INTEGRATED FINDINGS & DISCUSSION

6.1. Key findings

In this chapter I give a summary of the key findings of the study, highlighting the contributions made to the field, as well as where these findings were unanticipated or contrary to what has been found in the literature to date. These findings have been arranged by their empirical and methodological relevance. I have included data visualizations unique to this chapter to illustrate points in the discussion. The table below summarizes the objectives of the study, the chapter in which each objective is investigated, and the key findings related to each objective.

Table 14: Summary of study objectives and key findings

Study objective	Key findings	Chapter
1. **Objective**: Develop prospective and retrospective profiles of ACEs for the Bt30 cohort and explore the consistency across the timing and source of these reports of ACEs. **Research question**: What are the levels of consistency across prospective and retrospective reports of ACEs provided by a) caregiver, b) adolescents and c) young adults? **Hypothesis**: There is a greater degree of consistency between prospective and retrospective reports of ACEs by young adults compared to low to moderate levels of consistency displayed in the literature which focuses mainly on retrospective reports collected in middle-age or later.	• It was possible to aggregate prospective data on ACEs commensurate with the expanded ACEs questionnaire used retrospectively, due to the comprehensiveness and regularity with which this data was collected in the Bt30 cohort. • The two complete profiles of ACEs were compared and the findings indicated relatively low levels of agreement between sources of ACEs – caregiver report compared to child report – and between reports at different times – prospective reports compared to retrospective reports. • The hypothesis does not stand. Accounts of retrospective ACEs recalled in young adulthood do not show substantially greater levels of consistency compared to those recalled in middle-age or older populations.	3
2. **Objective**: Explore the prevalence and patterning of	• Prevalence rates of ACEs were found to be high, whether measured prospectively or retrospectively, higher than reported	5

Study objective	Key findings	Chapter
ACEs to determine their co-occurrence and clustering. **Research question**: What is the prevalence of ACEs in the sample, across time points and sources, and how do individual ACEs cluster? **Hypothesis**: The prevalence of ACEs is higher in the sample compared to studies conducted in high-income settings. There are also clear patterns of clustering of ACEs in the sample.	in HICs and similar to rates reported in other LMIC settings. • ACEs in the sample clustered distinctively into low-high:dysfunction-abuse categories. Participants were likely to either fall into a group with low levels of all ACEs, a group with high levels of all ACEs, a group with moderate exposure to ACEs mainly household dysfunction-related, or a group with moderate exposure to ACEs characterized by greater likelihood of emotional abuse and/or neglect. • The hypothesis stands, ACEs in this study were more prevalent and clustered in clear patterns.	
3. **Objective**: Examine the relationship between ACEs and a range of social and physical and mental health outcomes in the cohort. **Research question**: How are prospective and retrospective reports of ACEs differentially linked to social, physical and mental health outcomes and can one type of report be considered more reliable? **Hypothesis**: Both prospective and retrospective ACEs are linked to poorer outcomes, with the risk for poorer outcomes increasing in a grader manner. Given the issues with retrospective recall, associations between prospective ACEs and poor outcomes are stronger, advocating for the use of prospective or contemporaneous measures.	• The unique aspect of the data was the ability to link multiple measurements of ACEs to outcomes. • I examined the independent effects of exposure to single ACEs, the impact of cumulative exposure in the form of the ACE index, and the ways in which clusters of ACEs related to outcomes. All three types of measurements of ACEs were linked to poorer outcomes but in different ways. • The hypothesis stands in the sense that greater exposure to ACEs is linked to poorer outcomes in a graded manner, regardless of whether they are measured prospectively or retrospectively. • However, these relationships vary for different ACEs. For example, the association between high ACEs and poor mental health is strongest when measured retrospectively, but the association between high ACEs and criminality is strongest when measured prospectively.	4 & 5
4. **Objective**: Explore the potential role of recent stressors in the	• The initial hypothesis was that recent stressors would either act as a mediator	4

Study objective	Key findings	Chapter
relationship between ACEs and health and wellbeing outcomes. **Research question**: Do recent stressors measured contemporarily play a mediating or moderating role in the relationship between ACEs and poor outcomes? **Hypothesis**: Due to stress sensitization produced through exposure to high ACEs, recent stressors mediate or moderate the relationship between ACEs and poor outcomes.	exacerbating poor outcomes through high levels of ACEs exposure, or act as a moderator impacting the strength of the relationship between ACEs exposure and outcomes. • This study concluded that recent stressors in this sample acted as a confounder, impacting both the levels of ACEs reported and exacerbating poorer outcomes. • The hypothesis does not stand in this analysis, recent stressors play a confounding roles in the relationship between ACEs and poor outcomes.	
5. **Objective**: Identify sex differences in exposure to ACEs and related associations with poor outcomes. **Research question**: Are there gendered patterns of exposure to ACEs and their links to poor outcomes? **Hypothesis**: Given the literature on ACEs and outcomes, females and males will experience different levels and types of ACEs and vulnerability to poorer outcomes.	• Findings indicate that the prevalence of ACEs varied among males and females as did their clustering. • For the same level of ACEs exposure, associations with outcomes differed among males and females; for example, in some cases lower levels of ACEs exposure among males, were associated with the same negative outcomes that females displayed with high exposure to ACEs. • The hypothesis holds true. For example, females report similar levels of exposure to ACEs prospectively but lower levels retrospectively, but the likelihood that they will experience psychological distress is double that of male counterparts with similar levels of ACE exposure.	

6.2. Conceptual framework

The study's original conceptual framework (Figure 7) is inserted here for easier comparison with the revised conceptual framework (Figure 30). Modifications have been made based on learnings from this study. The first confirmed finding is that both prospective and retrospective reports of ACEs are indeed linked to a range of health and wellbeing outcomes. This was true when ACEs were measured as single exposures, cumulative exposures or clustered exposures. Differences were found in the type of individual ACEs and how they relate to poorer outcomes. I hypothesize these as proximal and distal ACEs, similar to the CDC-Kaiser ACE Study's separation of abuse-level ACEs and household dysfunction ACEs, and added to the revised conceptual framework. The difference is the inclusion of ACEs that occur in environments outside the home environment, in schools and communities, and as the expanded ACE index suggests, at the societal level. Proximal ACEs, those directly impacting an individual – physical, sexual, and emotional abuse – were more consistently, and to a stronger degree, linked to poorer outcomes. Distal ACEs, those occurring in their environment – exposure to IPV, household illness, chronic unemployment, etc. had a more additive effect. When experienced together in large numbers or combined with proximal ACEs, their impact on outcomes was greater and more wide-ranging than when assessed as standalone exposures.

The second confirmed finding is that sex differences were clear in the prevalence of ACEs and outcomes in the study sample, as well as the strength of associations between ACEs and outcomes and the types of negative outcomes that males and females are most likely to present with given high exposure to ACEs. Two notable examples are psychological distress and criminality. Despite females reporting similar exposure to ACEs prospectively and less exposure retrospectively, they were found to be twice as likely to experience psychological distress in adulthood compared to males with the same levels of ACE exposure. With respect to criminality, illustratively, females would have to experience 6 or more ACEs to be at a greater likelihood for engaging in criminality in this sample, while males would only have to report exposure to more than a single ACE to increase their likelihood for criminality.

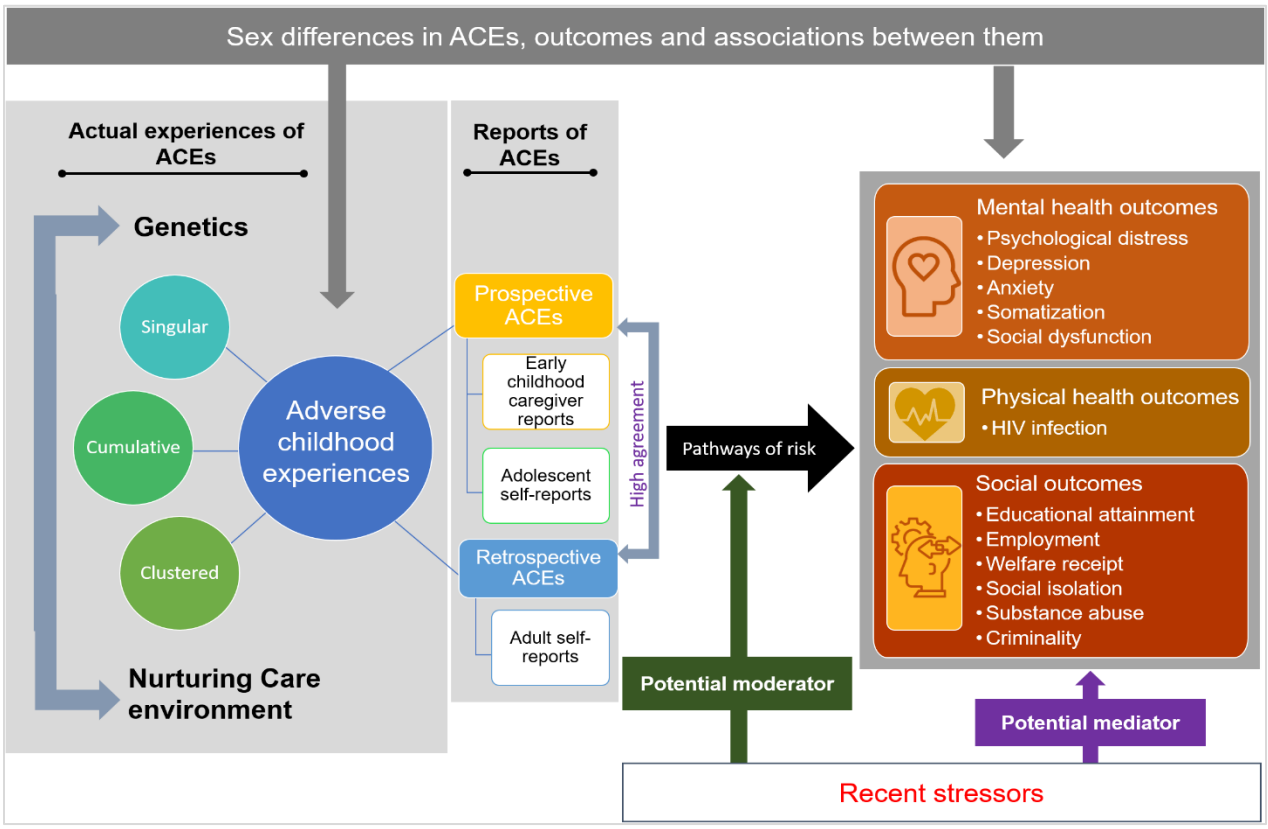


Figure 7: Conceptual framework

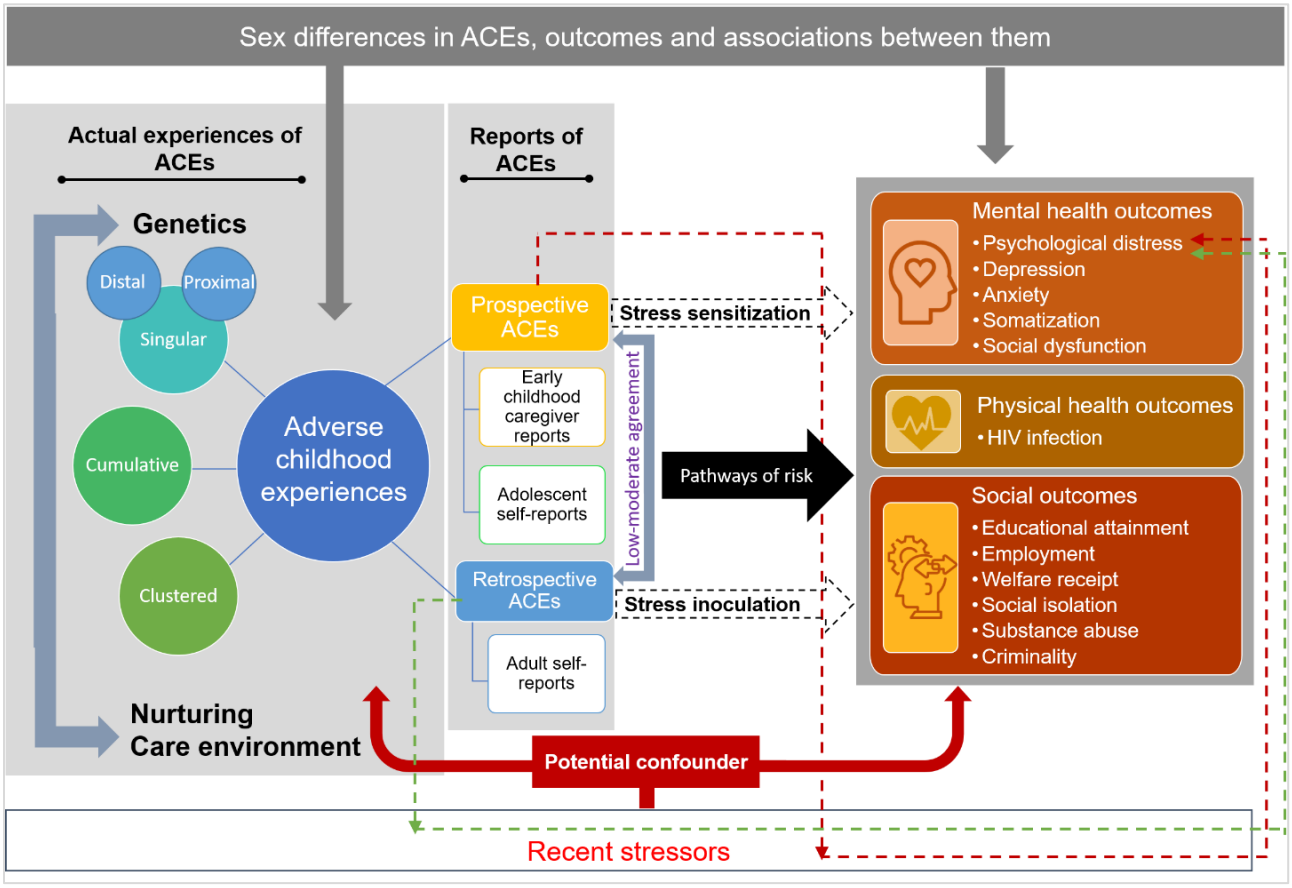


Figure 30: Revised conceptual framework

The first modification to the conceptual framework is that, while it was anticipated that agreement between prospective and retrospective reports would be relatively high since the latter were assessed at age 22 rather than in middle-age, which is common in many studies, agreement between the two accounts was found to be low to moderate with variation depending on the type of ACE assessed. More subjective experiences of adversity or those that children in a family may not be fully aware of, such as chronic unemployment, are subject to less agreement between sources, while objective events and experiences, like a household death, generally have more agreement. Part of the difference between prospective and retrospective account of ACEs is due to two separate, exclusive groups of individuals who are identified as 'high exposure' in only one account, and an overlapping group with 'high exposure' in both accounts.

It was also expected that contemporary stress would either mediate outcomes or moderate the relationship between ACEs and outcomes. In another modification, recent stressors were however found to have a confounding effect in the study – the amount of stress experienced in the time preceding retrospective recall of ACEs appeared to influence the levels of ACEs reported. Those individuals who reported a higher number of recent stressors also reported more ACEs. Possible explanations for this are that individuals with higher levels of ACEs continue to fare poorly in life and continue to experience more adverse events, and that hardship experienced before retrospective recall colours one's view on childhood and places more weight on experiences that one might not have otherwise perceived to be worth noting, or a mixture of both.

Adjusting for recent stressors in analysis indicated that contemporary stress strengthened the relationship between ACEs and poor outcomes. When these relationships were teased out further, it was clear that recent stressors played a different role in the relationship between prospectively reported ACEs and retrospectively reported ACEs and outcomes. For individuals who reported high prospective exposure to ACEs, high levels of recent stressors were linked to psychological distress, compared to those with low prospective exposure to ACEs, suggesting that exposure to stress in childhood sensitized these individuals to future stress and increased vulnerability for psychological distress. High levels of recent stressors had the greatest risk for psychological distress in the group who reported the lowest levels of exposure to retrospective ACEs, and the lowest risk for psychological distress in the group with moderate exposure to

retrospective ACEs, suggesting that moderate levels of stress induces some degree of resilience to stress in later life. The final modification to the framework reflects this by showing two separate pathways of risk to poor outcomes: a stress sensitization pathway from prospective exposure to ACEs (represented by the red dotted arrow lines) and a stress inoculation pathway from retrospective accounts of ACEs (represented by the green dotted arrow lines).

6.3. Emerging empirical themes: The burden of ACEs in South Africa

A number of interesting and important findings have emerged from this work. In this section, I summarize three of these themes. The first theme explores the prevalence of ACEs in South Africa. Previous work in this cohort has established the prevalence of ACEs reported retrospectively by a sample of participants. Here, I contribute to this literature by providing empirical evidence of the prevalence reported prospectively and show differences in prevalence when ACEs are measured, as they are wont to be, retrospectively. I describe the changes over time in reporting of ACEs in the same sample which has not been done previously in an LMIC.

In the second theme I show how ACEs cluster in the sample. Critics of the use of ACEs to identify vulnerable groups for the targeting of interventions have cautioned against using the index for such purposes. By understanding how ACEs cluster both quantitatively and qualitatively, I believe that their use to help identify vulnerable groups within populations is more suitable, even if it is to advocate for greater investment in preventive family- and community-centred interventions.

Through the third theme, I highlight the many associations found in this study between ACEs and poor social, mental and physical health outcomes. Studies in South Africa have demonstrated the links between individual adversities, usually physical and sexual abuse, and limited categories of adversity to outcomes in one or two domains of human functioning and development. The unique and important contribution that this study makes is to link a broad range of adversities, cumulatively, to a similarly broad range of outcomes spanning mental and physical health and social functioning indicators. Many of the outcomes measured here are challenges at the global level, but most, if not all, are key areas of concern in South Africa. With limited resources – both financial and capacity – I believe that illustrating the far-reaching consequences of adversity in childhood on education, productivity, crime, mental health, HIV

infection and more, can provide evidence to support streamlining resources into ensuring that children grow up in safe, secure and loving environments

6.3.1. Prevalence of ACEs in a South African birth cohort

Although empirical estimates of ACEs emanate largely from HICs, evidence of their prevalence in LMICs, including South Africa, has slowly increased. A small study of 250 HIV-positive youth (average age 16.3) in Soweto found that 90% of participants reported 4 or more ACEs [295]. Similar small but important studies have established the prevalence of ACEs among adult women and links to perinatal or infant poor health and development [296, 297]. The Azense cohort in a peri-rural area of KwaZulu-Natal estimated that by the age of 5, 3% of their participants had experienced four or more ACEs [298]. The study assessed what can be considered severe, or less commonly assessed ACEs (for example, the caregiver is HIV+ or has depression, food insecurity, the child has a major accident or illness), which may partly explain the low levels of ACEs reported. Using similar ACEs, and including parental death by homicide, a prospective study of 10-18-year-olds (mean age 13.45) estimated that about 3.5% of their cohort were exposed to 5 or more ACEs in Mpumalanga and the Western Cape [60]. While it is crucial to identify and include ACEs that are common or relevant in contexts such as sub-Saharan Africa – HIV-related indicators, orphanhood, food security, etc. – leaving out those perceived as less serious, but pervasive, underestimates the full extent of ACEs in LMICs. This is especially true since the concept of ACEs rests on the theory that the accumulation of adversity is associated with poorer outcomes. I was not surprised to find the prevalence of ACEs in this study population-based cohort to be high, comparable to estimates in other LMICs: 73% of individuals in Botswana [62], 75% in the Philippines [63], 77% in Honduras [64], 85% in Brazil [59], and 91% in South Africa [231] report at least one ACE in their childhood.

It was interesting to find that when cumulative ACEs are examined by developmental stage (Figure 31), the differences between gender increase as participants get older. In the early years, before age 11, when caregivers report on exposure to ACEs, girls and boys tend to be exposed to the same number of ACEs. During this period, more than half of the participants are exposed to 4 or more ACEs. While this figure drops significantly over time, early childhood is a critical and sensitive period during which disparities may be entrenched, meaning that these high levels of exposure should not be ignored. During adolescence, children in the cohort self-report on ACEs

for the first time. These are cumulative reports, not limited to the period of adolescence, but with possible bias based on what children were aware of and recall. This may explain to some extent, the drop in exposure to ACEs at the adolescent time point. And, although a slightly higher proportion of boys report four or more ACEs, exposure is relatively similar across gender. In young adulthood, a significantly higher proportion of men report exposure to four or more ACEs in their childhood compared to women.

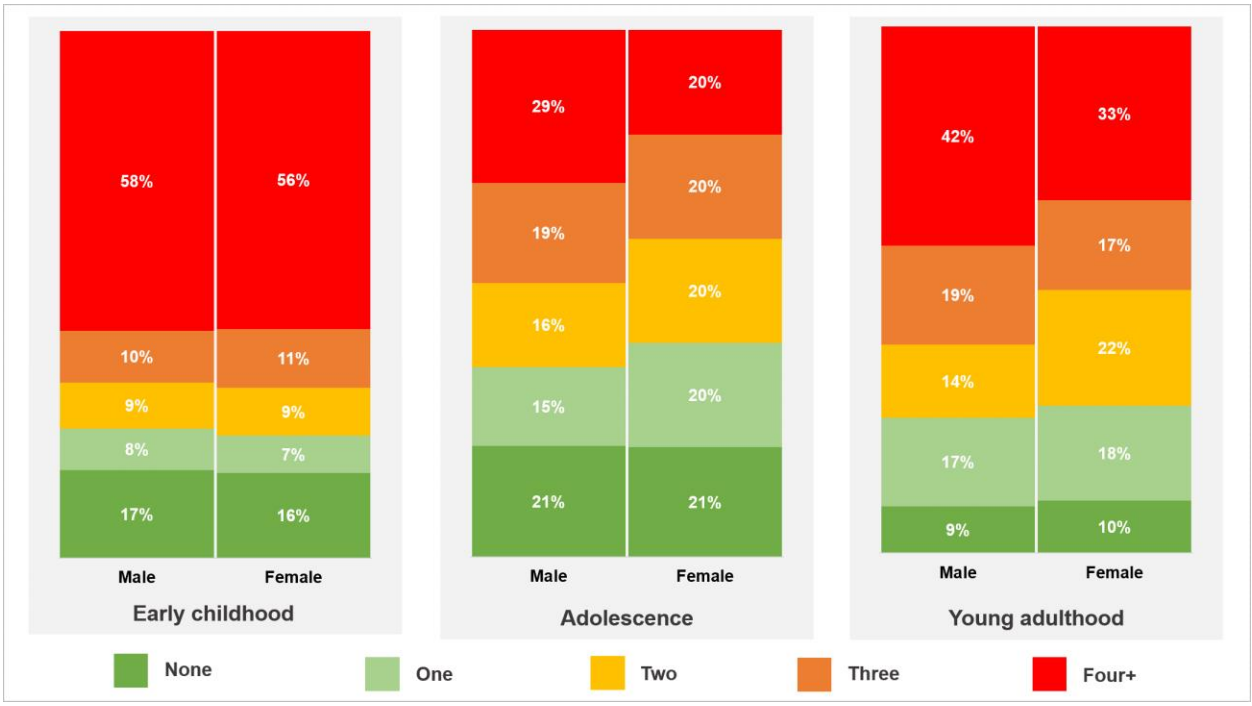


Figure 31: Prevalence of cumulative ACEs by gender and developmental stage

Examining the distribution of individual ACEs in the same way – by gender and developmental stage – gives a clearer picture that explains these differences to some extent (Figure 32). In early childhood, girls and boys are exposed to specific ACEs in similar proportions with small differences. Ten percent of boys, compared to 8% of girls, were exposed to some form of physical abuse; 6% of girls and 7% of boys experienced some form of sexual abuse, and 29% of girls, compared to 24% of boys, were separated from their parent/s for an extended period of time. Adolescent reports, up to age 18, introduce more variation in the types of ACEs experienced by gender. During this period, significantly more boys report some kind of physical abuse, legal trouble in the household, and almost twice the proportion of boys report exposure to community violence compared to girls. There are small gender differences (1-3%) in all other ACEs. I suspect part of the reason for this difference in exposure to ACEs, particularly violence-

related ACEs, between boys and girls in adolescence is that adolescent males are generally given greater independence and room to explore their social space than adolescent girls. This naturally leads to more opportunities and environments for potential risks or exposure to ACEs. Young girls are thought to be less able to protect themselves and their movement is restricted to some extent, a cultural phenomenon that has been documented in other urban settings [299].

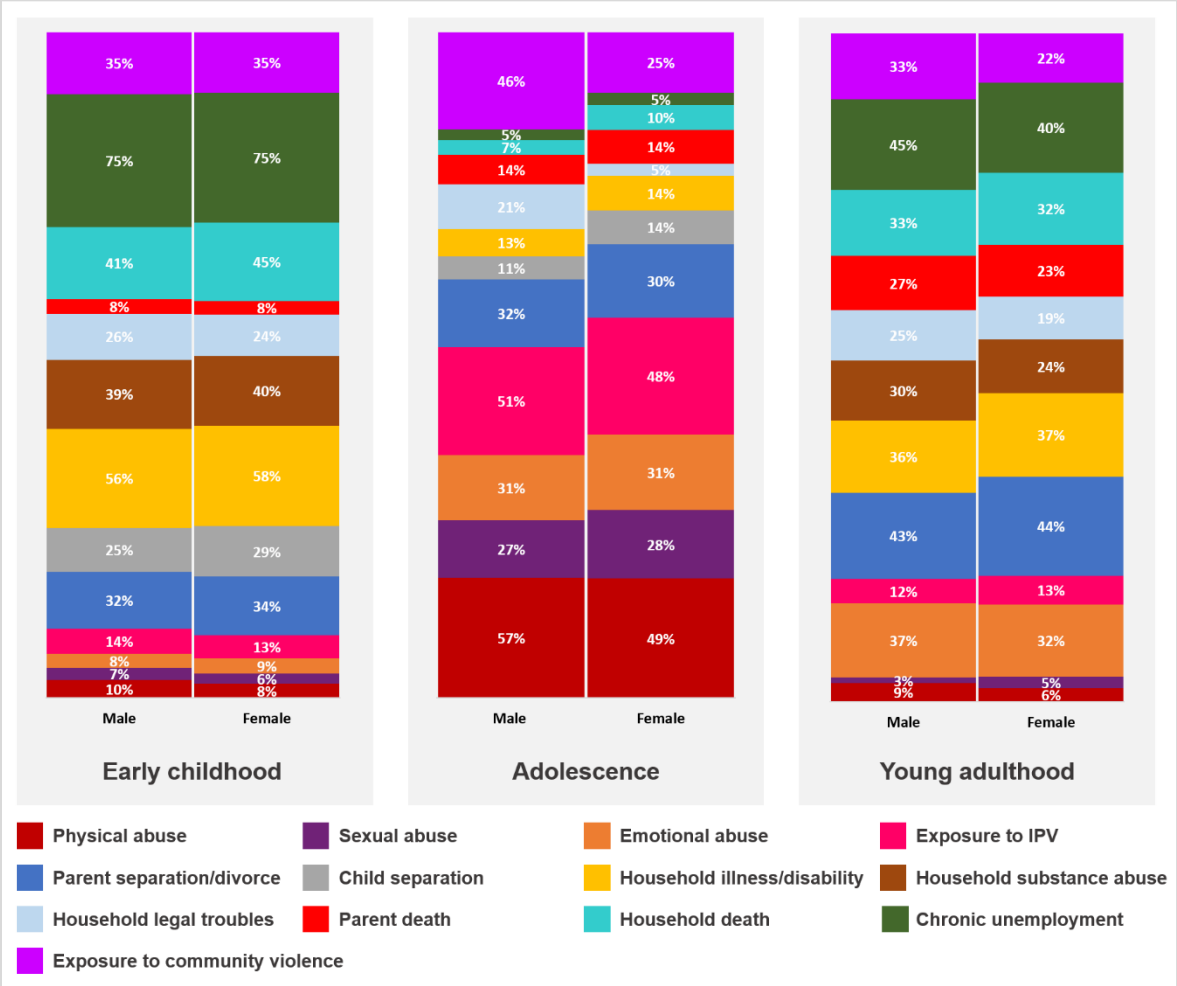


Figure 32: Prevalence of single ACEs by gender and developmental stage

The reported prevalence of some key ACEs decreased significantly from adolescence to adulthood, bearing in mind that adolescents are reporting prospectively up until that time point and adults are reflecting retrospectively on the first 18 years of their life. If anything, I would have expected prevalences to increase retrospectively given more time has passed and more opportunity for exposure is presented, but adolescents may not have been willing to disclose experiences as they occurred.

Physical and sexual abuse were strongly associated with incomplete schooling, unemployment, social isolation, psychological distress and HIV infection in young adulthood even though reports of these decreased by between 43% and 46% and 23% and 24% for females and males, respectively, from adolescence to young adulthood. Reported exposure to emotional abuse and/or neglect, also strongly linked to substance abuse, psychological distress, incomplete schooling, and criminality, increased when assessed retrospectively in young adulthood. Speculating on why these differences in reported prevalence are present is difficult and potential explanations for changes in reported exposure to ACEs over time are discussed under emerging methodological themes. What does appear to be true is that the timing of ACE measurement, whether prospectively or retrospectively, presents different pictures of exposure. Prospectively, 87% of participants report exposure to four or more ACEs, while retrospectively, this figure drops to 38%. Assuming that prospective measures are more accurate, retrospective reports underestimate the extent of adversity to which children in South Africa are exposed.

6.3.2. Clustering of ACEs

Given the increasing recognition of the inter-relatedness of ACEs, a key aim of the study was to examine how ACEs patterned prospectively and retrospectively, and whether these clusters could be linked differentially to outcomes in adulthood. Descriptively, plotting the distribution of different ACEs around a single ACE illustrates which ACEs tend to co-occur. This was a finding I anticipated, given that extensive literature shows the clustering of individual adversities, albeit using fewer adversities and most typically physical, sexual and emotional abuse. What is unique here, is the comparison of a fairly broader range of adversities, 13 in total, that include both abuse and household dysfunction variables.

In Figure 33, physical abuse is orbited by additional ACEs; those most likely to co-occur are closer to the centre. Fifty-four percent of individuals prospectively reported exposure to physical abuse. Of this group, 88% also reported chronic unemployment, 78% reported exposure to community violence and 62% a household death. Simply, experiences of physical abuse are likely to occur in the presence of poverty, violence, and a range of other household dysfunction indicators.

Plotting different ACEs at the center of the orbit shows slightly different clustering when ACEs are measured prospectively and starker differences when measured retrospectively (Figure 34),

likely due to the prevalence of most prospectively reported ACEs decreasing retrospectively. It is clear that for each ACE experienced, there are large proportions of individuals who report specific additional ACEs.

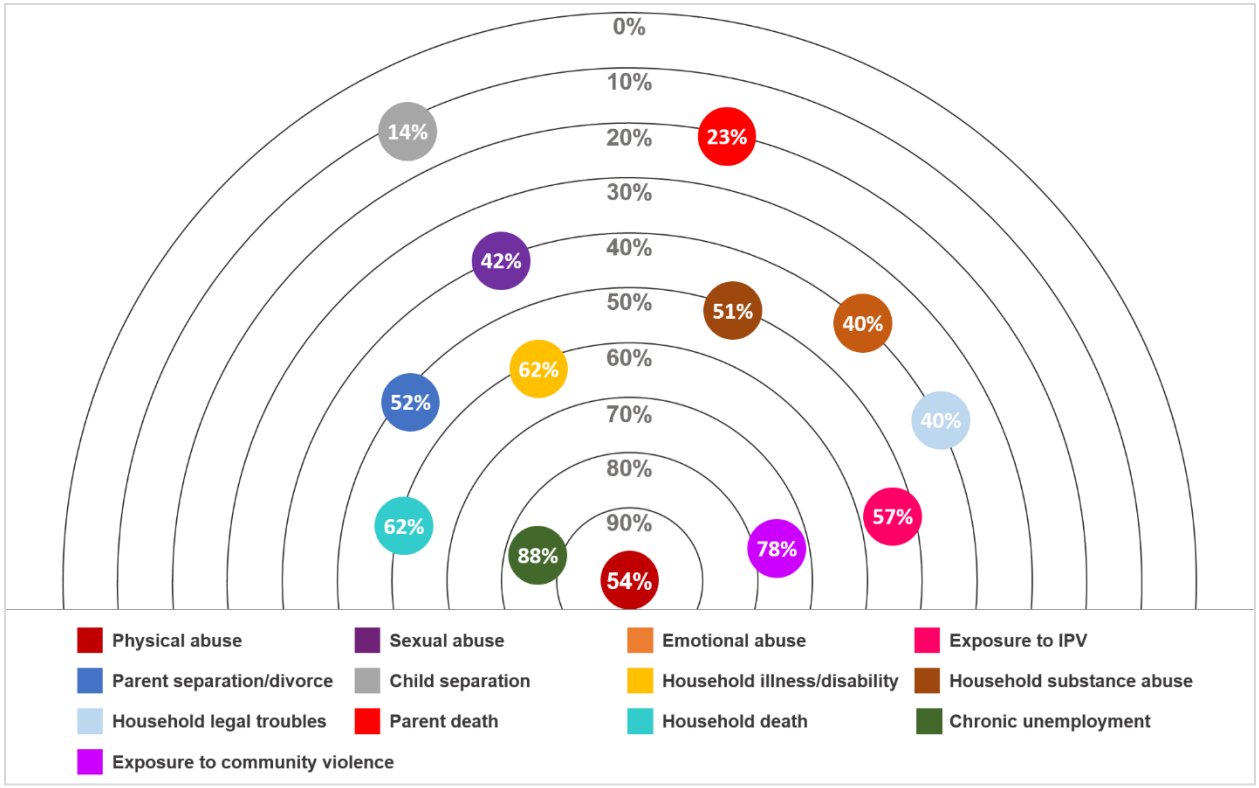


Figure 33: Co-occurrence of multiple ACEs when physical abuse is reported prospectively

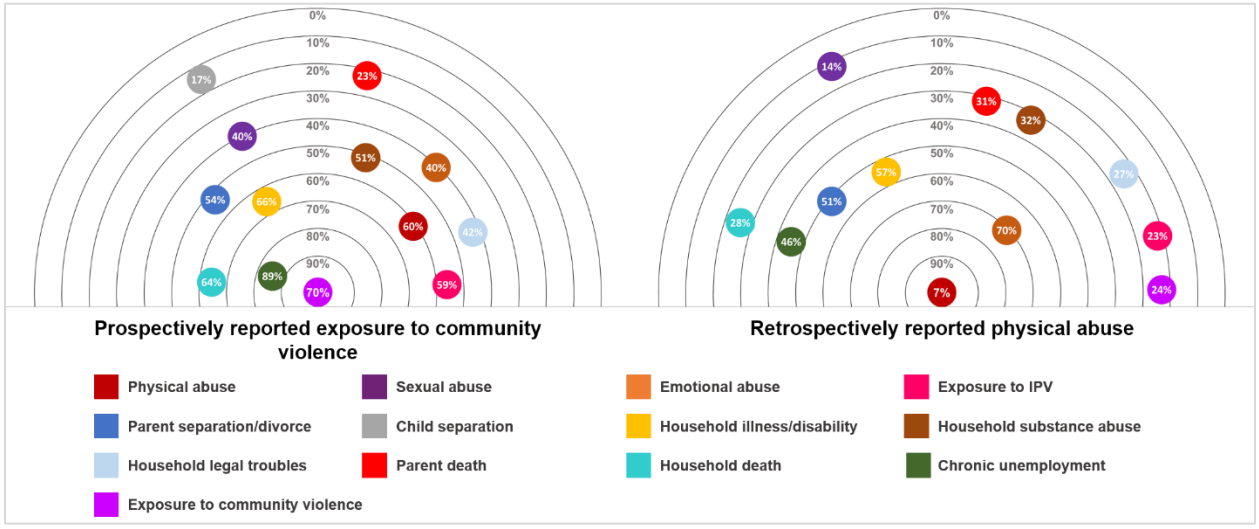


Figure 34: Co-occurrence of multiple ACEs when exposure to community violence is reported prospectively and physical abuse is reported retrospectively

When the odds ratios for additional ACEs, given a specific ACE, are plotted, the likelihood of co-occurrence can be estimated with more accuracy. For example, retrospectively reporting physical abuse leads to a 6.6 times greater likelihood of also reporting emotional abuse (Figure 36). Those who prospectively report exposure to IPV in childhood are 7.3 times more likely to also report high levels of community violence and 2.3 times more likely to report physical abuse (Figure 37). Depending on the ACE in question, the risk for each other specific ACE varies. What this method shows is the likelihood of additional ACEs independent of each other, given the presence of one specific ACE. Going beyond these bivariate estimations, another method to estimate the co-occurrence of ACEs is to examine latent patterns of adversity underlying a population.

Statistically analysing the clustering of ACEs to produce latent groups resulted in four distinct patterns of adversity experienced both prospectively and retrospectively. These groups are *low adversity*, *moderate adversity-dysfunction*, *moderate adversity-abuse*, and *high adversity* – a set of four prospective ACEs and a set of four retrospective ACEs. The groups were dichotomized using two indicators; the quantity of adversity and the type of adversity (Figure 34). The *low adversity* group was characterized by overall low levels of exposure to ACEs. For prospective classes, 8% of participants fell into the *low adversity* group and the likelihood of experiencing any single ACE ranged from 3% (child separation) to 38% (parental divorce or separation). Retrospectively, the *low adversity* group was much larger – at 42%, with the likelihood of experiencing a single ACE ranging from less than 1% (chronic unemployment and household legal trouble) to 31% (parental divorce or separation). The *moderate adversity-dysfunction* cluster was distinguished by high prevalence of household dysfunction ACEs. Prospectively, 40% of the participants fell into this group with an 88% likelihood of experiencing chronic unemployment, 66% likelihood of household illness/disability, 63% of household death and similarly high levels of household substance use and exposure to violence in the community. Retrospectively, this group comprised 27% of participants who were experiencing chronic unemployment and household legal trouble, as well as a 47% likelihood that their parents had divorced or separated. The *moderate adversity-abuse* groups were characterised by some household dysfunction but also direct abuse that was absent from the *moderate adversity-dysfunction groups.* Prospectively, 16% of participants fell into this group – they had an 83% likelihood of reporting exposure to IPV and 94% likelihood of reporting community violence; as

well as a 63% chance of physical abuse and 46% chance of emotional abuse. Retrospectively, this group comprised 16% of the sample who had a 55% and 56% likelihood of reporting parental divorce/separation and household illness/disability, respectively, and a 67% likelihood of experiencing emotional abuse. The *high adversity* clusters were prone to a wide range of ACEs. Prospectively the group was made up of 36% of the sample – this group had a 98% likelihood of reporting chronic unemployment, 97% likelihood of reporting exposure to violence, and more than 40% likelihood of reporting 8 additional ACEs, including physical abuse (66%), sexual abuse (48%), and emotional abuse (45%). Retrospectively the *high adversity* cluster comprised 15% of the sample with almost certain household legal trouble and chronic unemployment, 81% likelihood of emotional abuse and more than 40% likelihood of four additional ACEs.

In summary, there are relatively small groups of individuals, between 15% retrospectively and 36% prospectively, who experience high levels of all types of adversity. In the same sample, there are 8% (prospectively) and 42% (retrospectively) of individuals who go through their childhood with fairly low levels of adversity. As expected, individuals with low levels of exposure to ACEs fared relatively well in terms of outcomes and those with high levels of exposure were worst off. I was surprised to see that emotional abuse and/or neglect (in the orange in Figure 34), rather than physical or sexual abuse, was the key indicator that tipped groups experiencing moderate exposure to ACEs towards substantially poorer outcomes. Those with moderate levels characterized by household dysfunction still experienced poor outcomes but to a lesser extent. In his work, Fisher was similarly surprised when he found that dysregulated cortisol patterns – implicated in a range of psychological disorders – among institutionalized

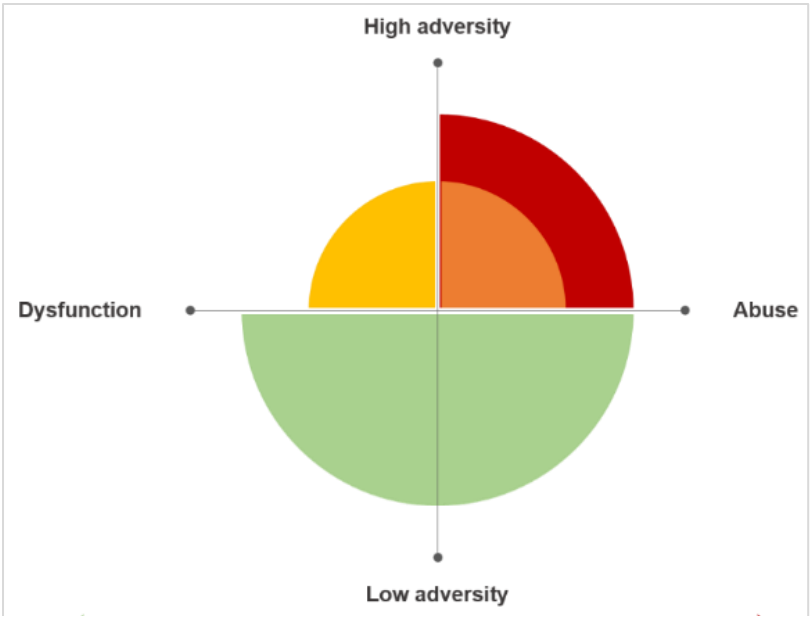


Figure 35: The clustering of ACEs into four groups and their relation to outcomes

children were linked not to physical or sexual abuse, but to early neglect [300]. Studies continue to document the many persistent physiological and psychosocial impacts of emotional abuse and neglect [301], further supporting the need for responsive caregiving in the early years.

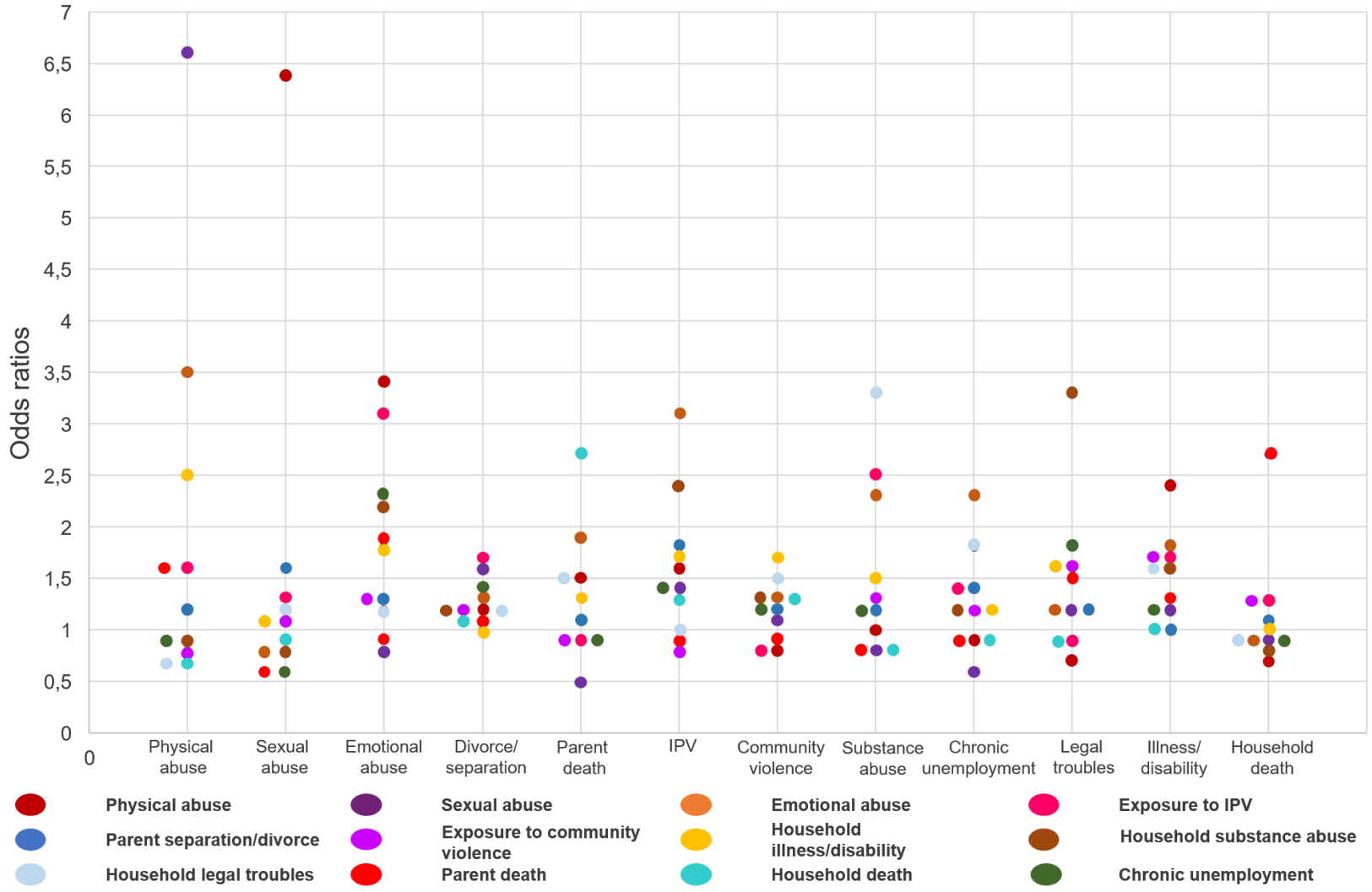


Figure 36: Likelihood of the co-occurrence of additional ACEs (y-axis) when one ACE (x-axis) is reported retrospectively

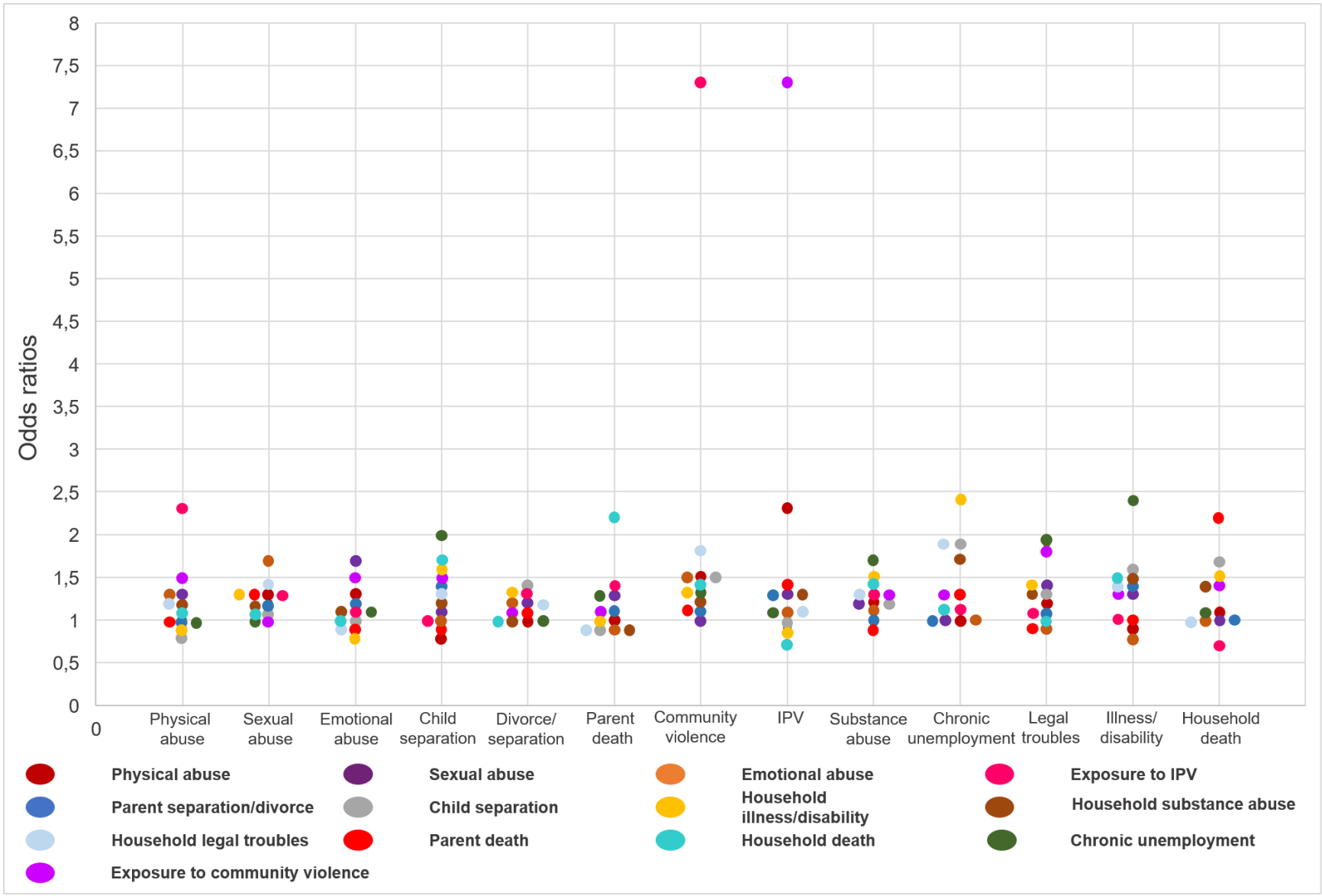


Figure 37: Likelihood of the co-occurrence of additional ACEs (y-axis) when one ACE (x-axis) is reported prospectively

6.3.3. ACEs and their impact on health and wellbeing

In this study, ACEs were found to be significantly associated with a range of health and wellbeing outcomes either as individual exposures, in combination, or cumulatively. The physical health indicator used was **HIV infection**. The prevalence of HIV infection was 14%, similar to that of the national population [270]. Females who reported sexual abuse retrospectively were 3 times more likely to be HIV positive, but there was no association between ACEs and HIV infection among males. Similar findings have been reported in other studies, including in South Africa [278, 280]. The pathways from abuse to infection have been hypothesized as direct – where infection results from rape or sexual assault; as well as indirect – where exposure to adversity disrupts psychosocial adjustment and other protective factors that would otherwise act as a deterrent to risky sexual behaviours.

Two measures of mental health were used in the study together assessing **psychological distress** in general, as well as symptoms of **anxiety**, **severe depression**, **somatization** and **social dysfunction**. The GHQ is used to detect minor psychiatric disorders in general non-clinical populations and is sensitive to short-term disorder. The GHQ was administered when the participants were 22 years old. The SRQ was developed by the WHO as an instrument to screen for mental disorders, and was administered when participants were 28 years old. Cumulatively, at age 22, exposure to four or more ACEs in childhood was associated with double the risk for psychological distress, including somatization, anxiety and severe depression. Physical, sexual and emotional abuse were significantly associated with an increased risk for severe depression and anxiety at age 22. Females in the sample reported similar levels of exposure to ACEs prospectively and lower levels of exposure retrospectively but were twice as likely to experience psychological distress compared to their male counterparts. The social dysfunction scale of the GHQ measures impairment or disruptions in social functioning – the extent to which one effectively engages in everyday activities satisfactorily and independently. ACEs were not related to the social dysfunction scale, although the socio-demographic variables included in the analysis were. Females were 1.5 times more likely to experience social dysfunction compared to males and those participants from higher SES homes and whose mothers had a higher level of education were less likely to experience social dysfunction. Almost 60% of the sample were above the cut-off on the social dysfunction scale, indicating a majority of young adults struggled with functioning in society. Young people may not be achieving the required levels of self-

efficacy and independence necessary to interact in society post-school. At 28 years of age, sexual abuse, emotional abuse, exposure to community violence, reported household substance abuse and severe illness/disability in the household were all risk factors for psychological distress. Reporting more than 3 ACEs or inclusion in any of the adversity clusters, apart from *low adversity*, were also associated with psychological distress. There were gender differences in the distribution of risk for poor outcomes. Prospectively reporting emotional abuse and exposure to community violence were significantly associated with psychological distress for males but not for females. However, retrospectively reporting emotional abuse was significantly associated with psychological distress for females but not for males.

The social and wellbeing outcomes assessed were educational attainment, employment, welfare receipt, social isolation, substance use, and criminality. Individual ACEs were linked to **incomplete schooling** – participants who reported physical, sexual or emotional abuse in childhood were more likely to not complete their secondary schooling. The *high adversity* group was also more likely not to have completed schooling compared to the *low adversity* group. Physical abuse and the occurrence of at least one household death in childhood were risk factors for **unemployment** in young adulthood. For male participants, household substance abuse in childhood was also linked to their unemployment in adulthood. Overall, exposure to a greater number of ACEs (6 or more) increased the risk of unemployment in the sample. In the case of **welfare**, receipt of the Child Support Grant was associated with experiences of sexual abuse in childhood in the female group. Women who reported chronic unemployment in the household as children, and those who fell in the *moderate adversity-dysfunction* and *high adversity* clusters, were also more likely to receive the welfare support in young adulthood. For females, reporting physical abuse as a child increased the risk for **social isolation** up to 6 times. No other ACEs were linked to risk for increased social isolation; though, parental divorce or separation was associated with decreased likelihood of social isolation in males. Childhood emotional abuse and exposure to community violence were predictive of **substance abuse** among young adult males but not females. The risk factors for **criminality** were emotional abuse, exposure to IPV, and presence in the *moderate adversity-abuse* and *high adversity* clusters – although only significant for males. The risk for criminality was only significantly greater for females when they reported six or more ACEs compared to less than six ACEs; for males, reporting more than one ACE significantly increased the likelihood of engaging in criminal behaviour in young adulthood.

6.4. Emerging methodological themes: Why measurement matters

A key thread throughout this study has been the methodological component. Having data available over 28 years to compare reports of adversity that occurred fairly contemporaneously to those recalled retrospectively, and subsequently linked to adult outcomes is a unique opportunity. While this has convoluted the analyses and made interpretation of results much more complex, the significant contributions that some of these findings make to a field still in its early years are worthwhile. The first of these methodological themes is the issue of quantifying adversity. This study built on the CDC-Kaiser ACE Study by incorporating chronic unemployment, in some sense a proxy for poverty, as an additional adversity, which is an important dimension of adversity, not captured in original index.

The second theme deals with how measurements of ACEs or adversity can be linked to outcomes. Supporting the ACE literature, I find that cumulative adversity is indeed associated with poorer adult outcomes in a graded manner. However, I maintain that, without dismissing the usefulness of the ACE index, there are individual ACEs – physical, sexual and emotional abuse, that independently have associations with poor outcomes that are comparable in strength.

In the third theme I explore the finding that agreement between retrospective and prospective accounts of ACEs is fairly low, contrary to what was expected given that retrospective reports were collected in early adulthood. This leads to the fourth theme focused on understanding why these differences exist and how they might relate to outcomes. An important thread is uncovered here, suggested by only one other study comparing similar studies with both prospective and retrospective reports — that the difference between reports are not wholly due to the reliability or unreliability of either method. Instead, a large part of the difference between reports can be attributed to each report identifying different groups of individuals, with some overlap. Using data from this study, this is illustrated here. Having consumed mountains of literature on recall bias, social desirability, infantile amnesia, and unrecovered memories, rejecting the notion that ‘one method must be better, more reliable, more valid, than the other’ only to find that prospective and retrospective reports identify two different groups of individuals who report high levels of ACEs and exhibit ‘matching’ poor outcomes, was surprising.

In the final theme in this section, I explore what I believe to be the most significant contribution of this work and a shift in thinking in the field. If we ignore for a moment why someone would

report adversity prospectively but not retrospectively, or vice versa, and look at the impact of recent stress on mental health, we reach an interesting conclusion. The influence of recent stress on those who report varying levels of ACEs differs depending on whether ACEs are reported prospectively or retrospectively. I suggest that for the group of individuals who report high ACEs prospectively, the pathway to poor outcomes is through the stress sensitization model – where high adversity in childhood sensitizes individuals to poor outcomes. For the group of individuals who report high ACEs retrospectively, I posit that the stress inoculation model is at play – those with moderate levels of ACEs show the lowest likelihood for poor outcomes given high levels of recent stress due to a 'steeling' effect.

6.4.1 ACEs as an index of adversity

One of the first critiques of the ACE index was the narrow range of adversities included in the index, limited to those at the individual-level and those in the home. Additional studies have since expanded the index to include ACEs that are prevalent in a wider set of contexts. The WHO's ACEs-IQ includes bullying and collective violence such as terrorism, war and genocide [5]. One study assessed the original ACE index in comparison to a second set of ACEs that included community-level factors such as peer rejection, peer victimization and community violence, and found that these too were linked to mental health symptoms in their sample [302]. An Expanded ACE index has been developed with community-level variables, and when assessed in low-income settings, the research supports well-established evidence that higher levels of adversity exist in lower-income settings. The implication for this is that certain demographic groups may be more exposed to specific adversities than others, and that these may go unmeasured when the conventional ACE index is applied [303]. Care was taken in this study to include those ACEs that were prevalent in this context but to maintain sufficient original ACE structure to allow for comparability across studies, particularly as this is one of few studies in an LMIC with such evidence. Community violence, chronic unemployment, parent and household death, and child separation were added to the ACE index used in this study. The premise of ACEs research is that physiological and neurological processes are disrupted by high exposure to adversity, leading to cognitive and emotional impairment that, when coupled with risk behaviours, result in poor health and wellbeing. These pathways cannot be fully understood if adversity is not measured comprehensively in different contexts.

6.4.2. Measuring ACEs

Comparing different measures of ACEs against the same outcomes proved to be a complicated but useful approach to understand how measuring adversity influences findings. A number of proximal individual ACEs were consistently linked to a range of poorer health and wellbeing outcomes. These include physical, sexual and emotional abuse/neglect and exposure to IPV. The original ACE study was careful to separate these abuse level variables from household dysfunction indicators in their analysis, but many studies use only the cumulative ACE score. In some ways, this masks the effect of particularly prominent individual adversities. It is useful to assess cumulative adversity. Cumulative measures show graded relationships, with incremental and sometimes exponential increases in risk for poor outcomes as exposure increases. When we are able to distinguish patterns in the types of adversities that might cluster together to lead to particular outcomes, we are able to isolate a group of ACEs that co-occur and in combination affect health and wellbeing.

What is clear to me from this work is that there are experiences of severe adversity such as physical, sexual and emotional abuse and neglect, as well as exposure to intimate partner violence in the home, that have persistent effects on health and wellbeing. When these are coupled with a range of household and community-level adversities, the additive effect increases the risk for poor outcomes substantially. Researchers caution that the ACE index should not be used to diagnose individual-level vulnerability, and that doing so would only lead to interventions that risk increasing disparities in health and wellbeing [304]. A key argument presented by researchers from the CDC-Kaiser ACE Study gives a clear explanation of this limitation [305]. Individuals with the same ACE score may differ in the timing of those exposures, the frequency of exposures, and the availability of protective factors to mitigate against these stressors. An individual with a single ACE may experience a severe form of maltreatment for a prolonged period of time while another may report a single low intensity, once-off ACE. For these reasons, the ACE score is not suitable as a screening tool or for assigning individual risk for decisions about treatment or services. The strength and value of the ACE score lies in its ability to estimate increasing population-level risk for health and social problems and provide a framework to understand how the prevention of ACEs, through intervention in complex social environments, can reduce the burden of global public health challenges [305]. At a practical level, the ACEs findings encourage family- and community-

centred interventions that holistically address a range of challenges and prevent or mitigate multiple adversities. At a theoretical level, the language in research around ACEs as an index belies the complexity of traumatic experiences. Issues of severity, frequency, and subsequent support play a part in the evolution of outcomes, which is not captured by the cumulative ACE score. In fact, in itself, the 'cumulative score' is misleading as a measure of total adversity experienced; rather it is a measure of the 'total range of adversity experienced that is being assessed' and should perhaps be referred to as a 'cumulative range of ACEs'.

6.4.3. Levels of agreement between sources of ACEs

The level of agreement between two sources of reports on ACEs was assessed at one time point – caregiver and child reports at age 11. Findings varied depending on the ACE assessed and whether the ACE was present or absent. For instance, there was high agreement between caregiver and child when reporting that the child had been separated from the family for an extended period of time, and there was also high agreement between caregiver and child on the absence of parental divorce/separation. Concordance on ACEs reported by caregivers and their children was greatest for objective experiences such as a death in the household. There was less concordance between sources with respect to experiences of household dysfunction. For example, the concordance rate for chronic unemployment was 19%, with about a fifth of caregivers and their children agreed on whether the household had experienced chronic unemployment. This was driven overwhelmingly by a large proportion of caregivers who reported chronic unemployment and children who reported that it was not something they experienced. Most likely this is due to the age at which the comparison was made. At age 11, it is probable that children are not fully aware of the financial status of the household. Over the first 11 years of their lives, caregivers report a considerable burden of care at the household level, with high prevalence of substance abuse, legal trouble, chronic unemployment, severe illness and/or disability, and family death. Although young children may not fully recall these experiences, as reflected in low agreement between sources, it is doubtful that this level of adversity did not have measureable impacts on their health and development, making the case for prospective accounts of adversity, particularly exposures during early childhood.

6.4.4. Differences between prospective and retrospective accounts of ACEs

The overall aim of this study was to understand the ways in which prospective and retrospective accounts of ACEs were linked to outcomes. Initial hypotheses raised questions about the reliability and validity of retrospective recall, which is open to a range of biases and subject to criticism. Findings from this study consistently showed that retrospective ACEs could be linked to multiple poor outcomes and that often these associations were stronger than those measuring prospective ACEs and outcomes. Substantial differences in the prevalence of ACEs between developmental stages were also found – prospective ACEs in early childhood were relatively moderate, and increased dramatically for many ACEs when measured prospectively in adolescence, and then decreased to close to pre-adolescent levels when assessed retrospectively. When the increase between early childhood and adolescence is examined, it is difficult to make a determination as to whether these changes reflect actual increases in experiences of ACEs, or changes in circumstances, or point to fluctuations in perception and disposition.

When combined prospective reports (early childhood together with adolescence) are compared to retrospective reports, the prevalence of all ACEs decreases, apart from parental death. The experiences that stay with us depend on a number of factors, including mood, whether one discusses the experience, etc., and literature suggests that these life stories are not fully formed until after adolescence [187]. This account is supported by the trend in prevalence found in this study. To summarize, retrospective accounts of ACEs are those that leave a mark on us and are recalled, while prospective accounts of ACEs – given consistent links to poorer outcomes – leave their mark but are not necessarily recalled later in life. Underlying this is the assumption that an individual might report one set of experiences prospectively and a slightly different set retrospectively.

Baldwin and colleagues [235] suggest that prospective and retrospective accounts of ACEs identify, to a large extent, two different groups of people. If individuals in the cohort are grouped into high and low ACE categories, both prospectively and retrospectively, with cut-offs at the average number of ACEs (6 prospectively and 4 retrospectively), the idea that prospective and retrospective reports identify two different groups can be examined. Figure 37 shows that prospective and retrospective accounts of ACEs identify the same individuals about two-thirds of the time – those who report low ACEs prospectively and retrospectively (40%) and those that report high ACEs prospectively and retrospectively (22%). This means that participants who report either high or low ACEs prospectively are the same individuals who report either high or low ACEs retrospectively. For 38% of the sample in this study, that is not the case. When ACEs are assessed prospectively a group made up of 23% of participants report high ACEs but do not report them retrospectively. When ACEs are assessed retrospectively a different group made up of 15% of participants report high ACEs but do not report them prospectively. The implications of these findings are that when we measure ACEs retrospectively we miss the 23% of participants who only report high ACEs prospectively and vice versa. This distinction between different groups with prospective ACEs and those with retrospective ACEs varies when individual ACEs are assessed, mirroring the findings on levels of agreement between sources of reports. For example, 84% of participants who prospectively report parent death also report retrospective parent death; only 15% of the participants who report parent death do so only either prospectively or retrospectively even though the accounts cover the same period of their lives.

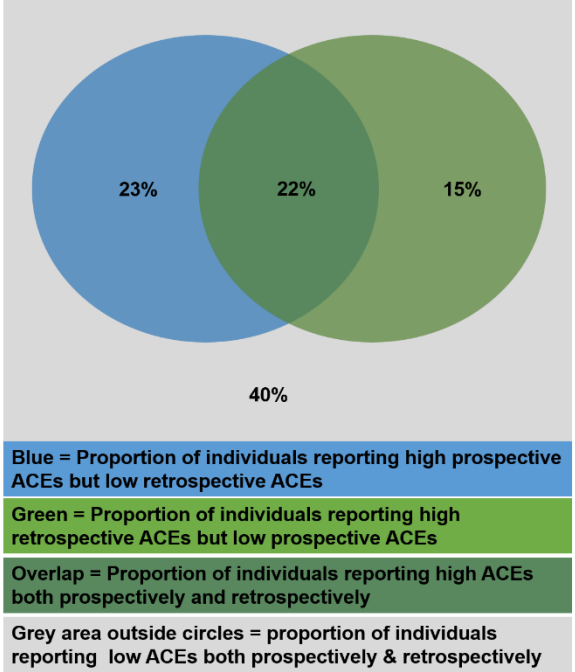


Figure 38: Diagram showing the proportion of individuals who fall into low and high ACE groupings prospectively and retrospectively

Another area where substantial differences between prospective and retrospective accounts were seen was in assessing the independent effect of recent stressors. The reasoning was that recent

stressors would either mediate the relationship between exposure to ACEs and outcomes or directly moderate the strength of that relationship. Neither mediation nor moderation effects were found. Instead, recent stressors appeared to act as a confounder in the relationship between ACEs and outcomes – the number of retrospective ACEs reported increased with the number of recent stressors reported, and recent stressors were significantly and independently linked to poor outcomes but also exacerbated the effect of ACEs on young adult outcomes. One explanation for this is the stress sensitization model, whereby adversity in childhood sensitizes individuals to subsequent stressors and increases vulnerability to negative outcomes [33, 212, 213]. The pertinent question to answer the stress sensitization hypothesis is 'do the effects of recent stressors have more severe effects on the health and wellbeing of individuals who have greater exposure to ACEs than those with lower levels of exposure to ACEs?'. Conversely, if a stress inoculation hypothesis were applied, we would expect that the recent stressors would have the lowest effect on health and wellbeing in the group with moderate exposure to ACEs.

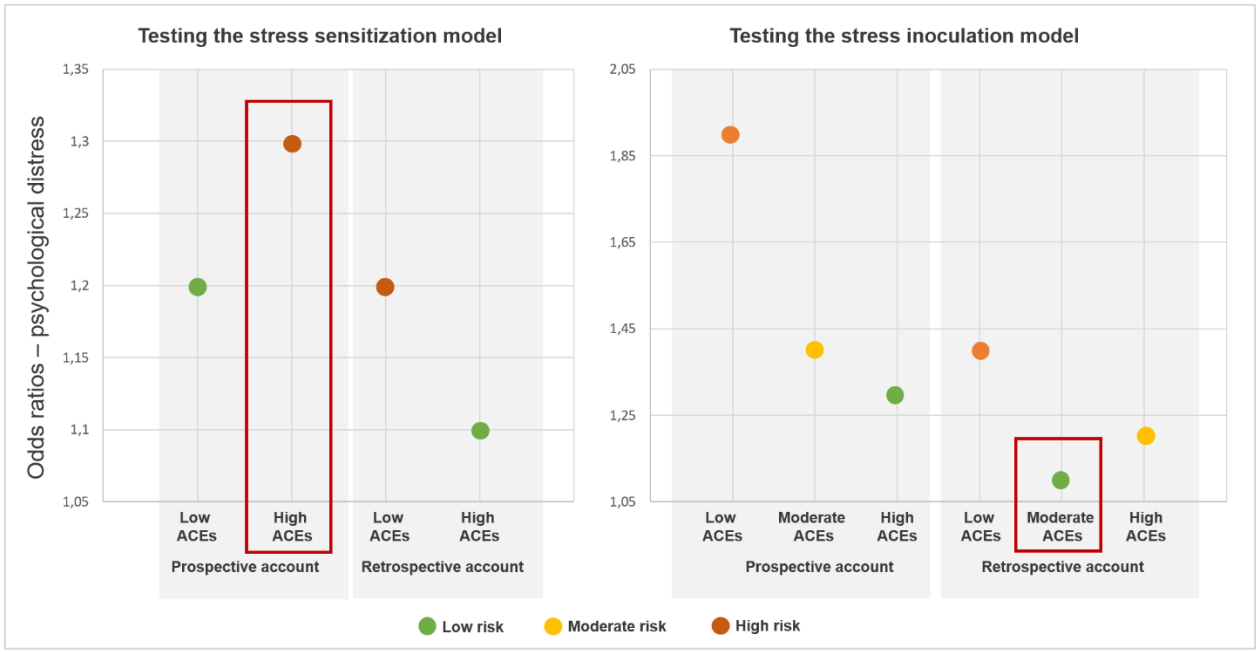


Figure 39: Testing the stress sensitization and stress inoculation models by assessing the effect of recent stressors on the risk for psychological distress compared between low ACEs, moderate ACEs and high ACEs

Preliminary testing of these two hypotheses on the ACEs data available in this study reveals interesting findings (Figure 39). The panel on the left, testing the stress sensitization hypothesis models the influence of recent stressors on the risk for psychological distress and compares this risk between the low ACE group and the high ACE group for both prospective and retrospective

accounts. As expected, for prospective accounts, recent stressors increase the risk for psychological distress in the high ACE group, supporting a stress sensitization model. Those individuals who report high ACEs prospectively in childhood are sensitized to future stressors and made vulnerable to psychological distress in adulthood. For retrospective accounts, the opposite is true – recent stressors are linked to increased risk for psychological distress among those participants who report low ACEs retrospectively. When the stress inoculation hypothesis is tested on the right, the effect of recent stressors on risk for psychological distress is compared between low ACE, moderate ACE and high ACE groups. As expected, the risk for psychological distress given high levels of recent stressors are lowest in the moderate ACEs group in the retrospective account – indicating that some exposure to stress in early life leads to subsequent stress resistance in later life. The same pattern is not seen in the prospective accounts. This initial crude analysis suggests that the pathways for poorer outcomes vary in different groups of individuals. Perhaps individuals who do not recall or report high exposure to ACEs retrospectively, but have reported them prospectively, have been sensitized to future stressors leading to higher risk for psychological distress. Those individuals who have not documented their prospective experiences of ACEs but recall them at a later stage have built up a resilience to subsequent stress that results in lower risk for psychological distress even in circumstances of high recent stressors. This is one potential explanation for the differences seen in the associations between prospective and retrospective reporting of ACEs, and although covered in a preliminary fashion here, warrants deeper investigation.

6.5. Implications

I propose a number of implications of the work presented in this study, organized here by their key empirical and methodological findings.

Table 15: Implications of findings

Key findings	Implications
Empirical findings	
• The prevalence of ACEs is high in this setting and linked to multiple social, physical and mental health outcomes.	• Given the range of domains associated with adversity in childhood – education, labour, health, social development, crime, etc. – evidence demonstrating this should feed into advocacy for increased coordination between different sectors in government and civil society in comprehensive efforts to promote health and wellbeing and harness human capital. • Comprehensive, integrated family- and community-centred policies that cut across sectors in government and civil society, rooted in frameworks like the NCF, are necessary to ameliorate the impacts of adversity in childhood. • Policy-makers are well-placed to facilitate cross-sector collaboration and sharing of resources for initiatives aimed at preventing or mitigating ACEs.
• The relationship between ACEs exposure and poor outcomes is graded in that greater exposure is associated with increased risk. Multiple household- and community-level adversities, such as substance abuse in the home and violence outside the home, work together to increase risk for poor outcomes. These adversities also tend to co-occur.	• Resources should be invested in family- and community-centred interventions to prevent and mitigate exposure to ACEs at these levels. This should include a trained adversity- and trauma-informed workforce in social services.
• Emotional abuse and/or neglect showed strong links with a broad range of outcomes in this study. When moderate levels of exposure to ACEs are experienced, the presence of emotional	• The NCF sets a blueprint for how to provide a safe, secure and nurturing environment for children with emphasis on ensuring that every child has at least one responsive, supportive caregiver in their lives. Evidence for interventions

Key findings	Implications
abuse/neglect significantly increases risk for poor outcomes.	aimed at strengthening responsiveness between mother and child is fairly robust but these require significant work to enable scaling up.
• Moderate levels of adversity to some kinds of adversity generate a resilience to future stress, protecting mental health.	• More research is needed to understand what this looks like but also what factors are present in a child's life that either push or pull them towards or away from poor outcomes. ACEs research supplemented with questions on positive experiences, the presence of peer support, a caring teacher, etc. can help elucidate mechanisms of risk and resilience.
Methodological findings	
• Cumulative measures of ACEs are important, but there are individual experiences such as physical, sexual and emotional abuse that are independently and strongly associated with increased risk.	• Exposure to physical, sexual and emotional abuse and neglect generally lead to immediate trauma and long-term consequences, is it essential that response services are able to identify these cases contemporaneously to treat and prevent further harm. • Analyses of ACEs data should explore the cumulative contribution as well as the independent contribution of these abuse-level ACEs so as not to obfuscate their impact.
• Both retrospective and prospective measures of ACEs are valuable for estimating the prevalence of cumulative adversities and their public health burden but each only captures a proportion of individuals with high exposure and associated poor outcomes. • Longitudinal prospective studies also identify a substantial group of individuals who don't report their exposure to ACEs retrospectively but still present with poor outcomes linked to ACEs.	• Until more work is done to validate the application of the ACE index, it should not be used in clinical settings to assess an individual's risk for any outcomes or as a diagnostic tool. • Used retrospectively, for population-based risk assessment, the rapid and easy to use ACE index is ideal for inclusion in national censuses and countries should be encouraged to include ACEs in their DHS and MICS assessments. The WHO has standardized an ACE module for this purpose which would generate country-comparable ACE data. Routine administrative data and large nationally representative surveys in high-income

Key findings	Implications
	countries facilitate estimation of ACEs at a population level, while in LMIC countries, assessments are restricted to smaller study samples. • Prospective studies are critical for building our understanding of the mechanisms that underlie the development of risk pathways, the factors that can mitigate against the development of risk, and the points across the lifecourse when intervention is most effective. Measuring the pathways of influence of adversities is only possible in long-term cohorts such as Bt30 and investment should be made in maintaining these cohorts and for research to be undertaken.

6.6. Future research

The scope of this study did not include an analysis of resilience and the push and pull factors that influence outcomes. Findings do indicate that moderate exposure to adversity may have a steeling effect against future stress to some degree, reducing risk for psychological distress. In addition, individuals who reported exposure to household illness/disability and IPV in childhood were less likely to be unemployed or experience social isolation; those who reported three ACEs, compared to those who reported none, were also less likely to experience psychological distress in young adulthood, and chronic unemployment on its own, prospectively measured, had a protective effect on somatization and anxiety. While these are crude associations that warrant further interrogation, there does appear to be some level of resilience to certain outcomes when childhood adversity is experienced at low-moderate levels. Further research is needed to fully understand the development of resilience in childhood and the role it plays in protecting health and wellbeing, particularly in contexts with high levels of adversity. Anda and colleagues [293] argue that "childhood adversities, though in all likelihood more frequent and intense in impoverished settings, make their own specific contribution to the developmental trajectory of individuals growing up in such environments. However, the likely bidirectional relationship

between poverty and adverse childhood experiences remains poorly researched and represents a knowledge gap that the current international initiative is well placed to fill." [p.95]. When the conceptualizations of ACEs are expanded to include those common in low-resourced, high adversity settings, the full extent of their prevalence and influence in low-income settings is visible. The ways in which poverty relates to ACEs, whether as an additional ACE adding to the cumulative effect, or as a risk factor exacerbating all other ACEs, and which has more deleterious effects on health and wellbeing, remain to be seen.

The conceptual framework used here recognizes the roles that gene-environment interactions and the nurturing care environment play in either increasing exposure to a range of adversities or increasing vulnerability to poor outcomes given high exposure to ACEs. However, these complex interactions and pathways were not tested. Similarly, the connecting steps on the ACEs pyramid, the disruptions of neurodevelopment and impairment of cognitive and psychosocial processes resulting from adverse experiences, leading to risky behaviour and ill health, have not been tested. More research is needed to establish these links in this cohort.

I propose that the next step in this work is to stratify the cohort into clusters of low risk and high risk individuals based on the ACEs data, with additional data on protective factors. To test for the hypothesized pathways from ACE exposure to poor physiological and psychosocial outcomes I propose that additional brain morphology and cortisol data are collected from the cohort in young adulthood to map the neurological and physiological development, differentiated by clusters of risk. This would be a novel study in South Africa and one that would provide evidence for the ACEs hypothesis that poor outcomes arise from disruptions in functioning that directly or indirectly affect health and wellbeing.

6.7. Strengths and limitations

This section deals with the strengths and limitations of this thesis as a whole. The data used here comprises the longitudinal, in-depth data necessary to investigate developmental trajectories and pathways of risk in a low-resourced, high adversity setting. The cohort is also relatively young, a period when longitudinal investigations into health and wellbeing are rarely applied, but when many of the risk factors for the foremost causes of illness and death are evident. Both prospective and retrospective measures of ACEs which may be key to understanding risk mechanisms, as demonstrated in this study, were also available. Given the advantages of a long-

term study such as this, one of the limitations is that I was not present to collect all of the data myself, particularly the early data, and had limited opportunity to collect new data in later years. These are issues common with the use of secondary data analysis and considerable effort is required to engage with the study team to properly understand the data. This thesis assessed outcomes in young adulthood due to exposure to ACEs in the early years, proposing potential pathways of risk but another limitation is that it does not comprehensively investigate additional factors and processes along that pathway. These may essential to understanding where and how to intervene to prevent or mitigate harm.

It is unavoidable that researchers working in long-term studies will eventually have used outdated measures for the assessment of childhood experiences when the time arrives to investigate adult outcomes. Given the straight forward yes/no questions posed over the years, assessing simple stressful events less prone to changes in conceptual thinking, the result was that many of the questions asked in the ACEs Survey were included at multiple points in Bt30 with little meaningful difference. At age 22 in 2012, the ACEs Survey was put to the cohort as in the CDC-Kaiser ACE Study. The WHO's development and dissemination of their ACE-IQ began many years later. This is another of this study's dual strength/limitations. When I began work on this in 2014, the ACEs field had just started a burst of energy that does not appear to be slowing down. The work in this study was contributing to current developments in the field, adding to a small but steadily growing evidence base with data not readily available in similar LMIC settings, a significant strength of this work. At the same time, as insights and advancements in the field were happening in real time, it proved a challenge to revisit gaps and opportunities in this study. For example, I missed the opportunity to use the WHO's ACE-IQ in our 22-year data collection wave because it didn't exist at the time. Where I thought I had struck a good balance of comprehensively assessing adversity in this context but maintaining the ability to compare findings to other studies with an additional five ACEs to the CDC-Kaiser ACE Study's 10 items, I later had doubts about whether this was the right decision. As work on the ACE Pyramid expanded to include societal level adversities, structural violence and racial discrimination, issues so pertinent to the South African context, I believe more in-depth qualitative work on the creation of indicators for structural ACEs from available data in Bt30, would have served the study well.

CHAPTER 7: CONCLUSION

This study finds that exposure to ACEs has serious and persistent implications for critical outcomes in adulthood, regardless of whether we measure them prospectively or retrospectively. Retrospective measures of ACEs are reliable in the sense that they identify groups of individuals who report exposure to adversity and consequently experience poor outcomes. However, a key conclusion in this work is that there is a substantial group of individuals who are not identified through retrospective assessments of adversity but who go on to experience poor physical and mental health and are vulnerable to a range of adverse social outcomes. Real time, multi-pronged approaches to preventing and mitigating the impacts of adversity in families, schools, and communities are not only necessary but have long-term returns on the investment in the form of human health, wellbeing and productivity.

This research supports the well-established literature pointing to early life experiences and childhood adversities setting the foundation for health and development and influencing life trajectories. Adverse experiences have been shown here to, in combination and accumulation, have an impact on health and wellbeing. Specific individual ACEs can be teased out for their independent effect on outcomes, but the additive effects of multiple adversities lead to almost exponential increases in the risk for a range of negative physical and mental health and social outcomes.

How adversity is measured and the context in which it is measured may provide insight into the relationship between adversity and outcomes. When the conceptualizations of ACEs are expanded to include those common in low-resourced, high adversity settings, the full extent of their prevalence and influence in low-income settings is visible. The ways in which poverty relates to ACEs, whether as an additional ACE adding to the cumulative effect, or as a risk factor exacerbating all other ACEs, and which has more deleterious effects on health and wellbeing, remain to be seen.

The findings here provide important links from South Africa's context of high levels of violence in all forms and multiple hardships that families with large burdens of care endure with little support, to many of the human capital outcomes on which productive, healthy and happy lives depend. Born at the dawn of democracy, with anticipation for opportunity, many of the children in this cohort were raised in contexts of adversity that may have felt normative in those settings.

Regardless of whether these experiences leave enough of a mark to be recalled later in life, the strain of cumulative adversity has had persistent and serious effects on their mental health, and colloquially, their ability to finish school, find a job and stay out of trouble.

CHAPTER 8: REFERENCES

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CHAPTER 9: APPENDICES

Appendix 1: Publication 1 - An analysis of retrospective and repeat prospective reports of adverse childhood experiences from the South African Birth to Twenty Plus cohort.

Appendix 2: Publication 2 - Secondary analysis of retrospective and prospective reports of adverse childhood experiences and mental health in young adulthood: Filtered through recent stressors.

Appendix 3: Publication 3 - The long-term health and human capital consequences of adverse childhood experiences in the Birth to Thirty cohort: single, cumulative and clustered adversity.

Appendix 4: Declaration of student's contribution to article and agreement of co-authors

Appendix 5: Adverse childhood experiences and recent stressors survey questions

Appendix 6: Physical and mental health and social outcomes survey questions

Appendix 7: Ethics clearance certificates

Appendix 8: Supplementary material to Chapter 4

Appendix 9: Supplementary material to Chapter 5

Appendix 1: An analysis of retrospective and repeat prospective reports of adverse childhood experiences from the South African Birth to Twenty Plus cohort

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RESEARCH ARTICLE

An analysis of retrospective and repeat prospective reports of adverse childhood experiences from the South African Birth to Twenty Plus cohort

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Abstract

Most studies rely on cross-sectional retrospective reports from adult samples to collect information about adverse childhood experiences (ACEs) to examine relationships with adult outcomes. The problems associated with these reports have long been debated, with only a few studies determining their reliability and validity and fewer still reaching consensus on the matter. This paper uses repeat prospective and retrospective reports of adverse childhood experiences from two respondent sources in the South African Birth to Twenty Plus (Bt20+) cohort to explore agreement and concordance in the prospective reporting of ACEs by caregivers and respective children as adolescents and then as young adults. The findings demonstrate little overall agreement between prospective and retrospective accounts of childhood experiences, with 80% of kappa values below the moderate agreement cutoff (k = .41). The highest levels of agreement were found between prospective and retrospective reporting on parental and household death (kappas ranging from .519 to .944). Comparisons between prospective caregiver reports and retrospective young adult reports yielded high concordance rates on sexual and physical abuse and exposure to intimate partner violence (91.0%, 87.7% and 80.2%, respectively). The prevalence of reported ACEs varied with the age of the respondent, with adolescents reporting much higher rates of exposure to violence, physical and sexual abuse than are reported retrospectively or by caregivers. This variation may partly reflect actual changes in circumstances with maturation, but may be influenced by developmental stage and issues of memory, cognition and emotional state more than has been considered in previous analyses. More research, across disciplines, is needed to understand these processes and their effect on recall. Long-term prospective studies are critical for this purpose. In conclusion, methodological research that uses a range of information sources to establish the reliability and validity of both retrospective and prospective reports - recognizing that the two approaches may fundamentally answer different questions - should be encouraged.

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Introduction

Made familiar by the Centers for Disease Control and Prevention (CDC) and Kaiser Permanente's Adverse Childhood Experiences (ACE) study [1], retrospective adult reports of childhood experiences of abuse, neglect and household dysfunction have been linked to a range of adverse social and health outcomes in later life [2–21], studied predominantly in high-income countries. Growing evidence from around the world suggests that ACEs tend to cluster together [11, 17, 22, 23]; for example, that childhood sexual abuse often occurs in the presence of other ACEs [1], and that the risk for adverse outcomes increases in a strong and graded manner as the number of ACEs increase [22, 24]. The ACE score, the total number of ACEs to which an individual reports having been exposed before the age of 18, enables one to examine the cumulative impacts of ACEs on later life outcomes.

In recent years a number of South African studies have assessed the impact of childhood adversity on health and wellbeing [25, 26], including one longitudinal prospective study of cumulative adverse childhood experiences [27]. The associations between exposure to adverse childhood experiences and negative outcomes follows a pattern similar to other countries. Since the inception of its democracy more than 20 years ago, South Africa has transitioned rapidly from a setting characterized by poverty, underdeveloped infrastructure and limited resources. Yet high levels of inequality and unemployment, along with a generalized HIV epidemic adding another dimension to the experience of adversity [10, 16, 25], present conditions where exposure to multiple and concurrent adverse childhood experiences is prevalent around the country [27].

The few long-term studies that have been conducted in low- or middle-income countries (LMICs) tend to examine associations between retrospectively reported single childhood adversities and outcomes. In countries that participated in the Global School-based Student Health survey in 2003/2004, specifically Namibia, Swaziland, Uganda, Zambia and Zimbabwe, associations were found between 12-month retrospective reports of exposure to physical and sexual violence with mental health, suicide ideation, substance use, multiple sex partners and a history of sexually transmitted infection among 13-15-year-olds [28]. Other studies have linked reports of early adversity to personality and current major depressive disorders in Togo [29]; a range of sexual risk behaviours, alcohol and drug use, and intimate partner violence in South Africa, Tanzania and Zimbabwe [16]; and elevated likelihood of adult substance use disorders in Nigeria [13]. In South Africa, exposures to adverse experiences in early life have been associated with a number of poor adolescent and adult outcomes, including HIV risk [10], methamphetamine use [12], psychological distress [30], the perpetration of both non-partner and partner rape [26], and increased risk of psychiatric disorder [17].

There are some prospective studies linking exposure to adverse childhood experiences to social and health outcomes such as psychological, behavioural, and academic problems in adolescence [31]; HIV risk behaviour at age 14 [32]; obesity and type 2 diabetes [33]; mental health [34]; premature mortality [35]; chronic pain [36]; and age-related disease [37]. Most often this prospective data comes in the form of school records, which are frequently incomplete and focus on a small set of ACE variables, or historical court and child protection service records which are typically available when cases are extreme [38, 39]. There are far fewer prospective studies of adverse childhood experiences than it may appear since multiple publications using prospective data is often from a single study, as with the 1958 British birth cohort [32, 33, 35, 36, 40]. We could find no prospective or quasi-prospective studies on adverse childhood experiences and later life outcomes located in LMICs. In their 2012 meta-analysis, Varese and colleagues [41] found eight prospective studies linking childhood adversities to psychosis from the Netherlands (3), the United Kingdom (2), Finland (1), Germany (1) and Australia (1).

The reliance on retrospective recall raises questions about the extent to which reports are valid (accurate), reliable (consistent) and free from bias relevant to the hypothesis at hand. Additional methodological challenges include the possibility of confounding factors accounting for both early adverse experiences and later outcomes examined. Validity of reports depends on a number of factors, such as memory, cognitive function at the time the event occurred, and subsequent life experiences that may change a person's outlook [42–44]. For instance, people who experience adverse health and social outcomes in later life may be more likely to recall and/or report having experienced adverse experiences during childhood [19]. Inconsistencies affecting the reliability of retrospective responses can occur for a number of reasons. Apart from deficits in memory due to a lapse in time, repression of memories may result from stressful events experienced [45]. Recall is also altered by subsequent events, whether experiences at the time or later were discussed with others or overheard, and if help or treatment was sought. Rothman and Greenland [46] propose that some of these factors might lead to misclassification of exposed individuals as unexposed, leading to a downward bias of the association between ACEs and various outcomes, a finding also reported by others [4, 47]. In contrast, the dilemma of false-positives or over-reporting is virtually impossible to establish [48].

Some research has been conducted to ascertain the reliability and validity of retrospective ACE reports. In terms of validity, it has been found that even where childhood sexual abuse has been documented, retrospective recall, even in young adulthood, can be low [49, 50]. The validity of retrospective reports is difficult to confirm [51], but establishing reliability over time of retrospectively reported adverse childhood experiences is a more manageable task. This has been done by examining the reliability of reports using a test-retest paradigm where the same respondents are questioned on two occasions [52–63]; assessing reliability using two separate measures of adversity [64, 65]; and looking at the concordance or corroboration between two different report sources [66]. A further limitation is that most studies examine the reliability of reports on only one or two adverse experiences. Fewer studies assess reliability over time of a range of childhood experiences [61].

Studies comparing the prevalence of reported adverse childhood experiences using historical prospective data such as court records and retrospective reports have found substantial under-reporting in the former [67]. Few direct comparisons of prospective and retrospective data on childhood adversities and their consequences in a single sample have been conducted. In four studies comparing documented records of child sexual and physical abuse and neglect [68–70] and child hospitalization [71] significant associations between childhood adversity and negative outcomes were found when retrospective self-reports, but not prospective documented records, were analysed.

The aim of this analysis is to use the opportunity afforded by the Birth to Twenty Plus (Bt20+) data over 22 years to explore levels of agreement and concordance in prospective reporting of ACEs from children and caregivers at different time points with retrospective reports in young adulthood.

Methods

Study design and participants

Ethics clearance was obtained from the Witwatersrand University Committee for Research on Human Subjects (protocol number: M140726). The Bt20+ study began as Birth to Ten, a birth cohort study in Soweto-Johannesburg with the objective of tracking a group of urban children in South Africa at a time of very significant political, social, demographic and health transitions, born as they were just weeks after Nelson Mandela's release from prison. Extended to

Bt20+, the sample consists of all singleton children born to mothers who were residents of Soweto-Johannesburg in the 7-week enrolment window and who remained in the area up until the child reached 6 months of age. The Bt20+ cohort is now 26 years old, and includes the third generation of children born to the original cohort. A detailed description of the study, its birth cohort and participants is published elsewhere [72]. The sample analysed in this paper comprises 1595 participants who were surveyed at the 21-22-year data collection point, when they provided retrospective data on adverse childhood experiences, and prospectively throughout the cohort study. Prospective reports of ACEs from parents and children were recorded at six time points across childhood and adolescence. Written informed consent was obtained from parents and guardians of all children included in the study on behalf of parents and their children. Informed assent, and later consent at the appropriate age, was obtained from children for their participation in the cohort. Since a child may not be raised by a biological parent for a number of reasons, the term *caregiver* will be used to refer to the primary caregiver of the child.

Measures

Adverse childhood experiences

Bt20+ collected data on a wide range of topics including variables related to adverse childhood experiences, initially from caregivers and subsequently from the Bt20+ respondents themselves. These variables include exposure to crime and violence, experiences of emotional, sexual and physical violence, poverty, family dysfunction and more. Adverse childhood experiences are defined in this study, in the same way as in the original ACE study: as physical abuse, sexual abuse, emotional abuse, physical or emotional neglect, and household dysfunction in the form of experience of divorce or parental separation, exposure to intimate partner violence (IPV), experience of living with a chronically ill or disabled individual or an individual with substance abuse problems, parental death, household legal trouble, and chronic household unemployment.

Table 1 shows the child's age at which these variables were assessed. At Bt20+ child age five, seven and 11 years the caregiver was asked a number of ACE questions relating to her child. Between 11 and 18 years of age, the child responded to a number of ACE questions. The

Table 1. Child ages at time of caregiver, adolescent & young adult ACE reports.

ACE variable	Caregiver reports			Adolescent reports			Young adult report
	5	7	11	11	15	18	23
Physical abuse	●	●		●	●	●	●
Sexual abuse	●	●		●	●	●	●
Emotional abuse	●	●			●	●	●
Divorce/separation	●	●	●	●	●		●
Exposure to IPV	●	●	●		●	●	●
Household substance abuse	●	●	●				●
Serious illness or disability in the household	●	●	●	●			●
Household legal trouble	●	●	●		●	●	●
Chronic unemployment	●	●	●	●			●
Parental death		●		●	●	●	●
Death in the family/household	●	●	●	●		●	
Separation from parents	●	●	●	●			
Exposure to violence and crime	●	●	●		●	●	●

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caregiver and adolescent reports are regarded as prospective reports of ACEs. At the 22 year data collection wave, a retrospective report on adverse experiences during the first 18 years of life was obtained from Bt20+ respondents through a set of questions modelled on the CDC/Kaiser Permanente ACE questionnaire. S1 Text lists the ACEs-related survey questions used throughout the study.

In sum, three accounts of ACEs are examined and compared: caregiver reports about the child's environment and experiences at the time; young adolescent reports about their own environment and experiences at the time, and young adult retrospective reports about their environment and experiences in the first 18 years of life. Prospective caregiver reports and prospective adolescent reports are individually compared to retrospective young adult reports. Combining the caregiver and adolescent self-reports a prospective report across childhood is also compared to young adult retrospective reports about the same period.

Analysis

Descriptive statistics were used to summarize caregiver and adolescent reports of exposure to ACEs at different time points as well as the prevalence of reported ACEs. Cohen's kappa was calculated to compare item agreements between prospective caregiver and adolescent reports of ACEs with retrospective young adult reports of ACEs. Kappa examines agreement adjusting for chance and has been used in several other studies of the reliability of reports of childhood experiences [52, 61, 73, 74]. We followed Landis & Koch's [75] classification on the strength of agreement. The percentage of item agreement between both time points, or concordance rate, was also calculated as suggested by de Mast [76] to overcome Kappa values that may be affected by the number of '*yes*' responses that are due to rare events or very common events resulting in artificially low kappa values. S1 Dataset contains the minimal data used in the analysis.

Results

Fig 1 shows the prevalence of reported experience of ACEs by caregivers about children's lives up to age 11 years. Blank spaces indicate that questions on this ACE were not asked at a particular age. A combined caregiver report is calculated as the prevalence of *ever* reporting an ACE in the 6-year period between 5 and 11 years. Divorce/separation, household substance abuse, serious illness or disability in the household, death in the household and exposure to violence and crime were reported at roughly the same rates when children were 5, 7 and 11 years old. Chronic unemployment was the most frequently reported ACE at all time points, increasing to 81.9% when the caregiver reports at child age 11 years. Combined time points show that about 82% of children younger than 11 were living in a household that reported chronic unemployment at least once.

Fig 2 looks at the average prevalence of ACEs reported by adolescents prospectively between the ages of 11 and 18. During their teenage years, young people are more likely to report the death of a parent, as well as increased exposures to violence, including sexual and physical abuse. Reports of physical abuse increase from 19.0% at 11 years to 44.4% at 15 years, decreasing to 22.1% at 18 years. Reports of sexual abuse by adolescents quadrupled from 9.3% at 15 years to 40.6% at 18 years. The combined adolescent report shows that 48.6% of adolescents report exposure to physical abuse at least once during the 11–18 year period.

Young adult retrospective reports of ACEs occurring before they turned 18 are shown in Fig 3. Divorce/separation and chronic unemployment in household are the most frequently reported ACEs at 44.9% and 43.5%, respectively. Retrospectively reported physical abuse is much lower - at 7.8% - compared to combined adolescent reporting of physical abuse at 48.6%.

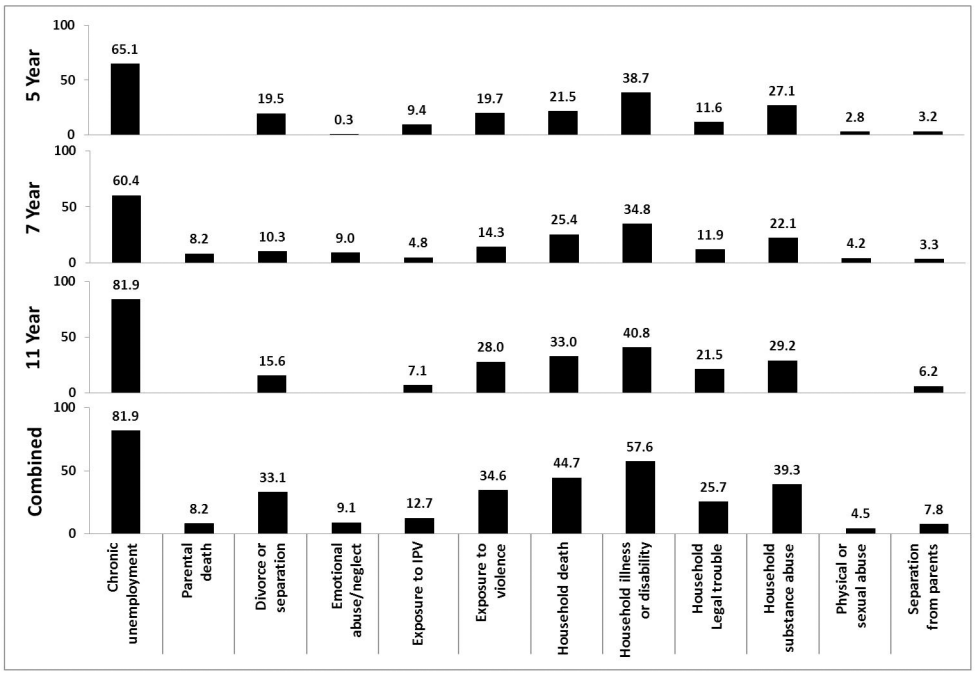

Fig 1. Prevalence (%) of ACEs at various child ages reported by caregiver in the first 11 years.

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Fig 4 below shows the prevalence of reported ACEs by source - caregiver, adolescent or young adult - and time point - prospective or retrospective. Across sources there is consistency in the reporting of exposure to violence and family instability, namely divorce/separation and

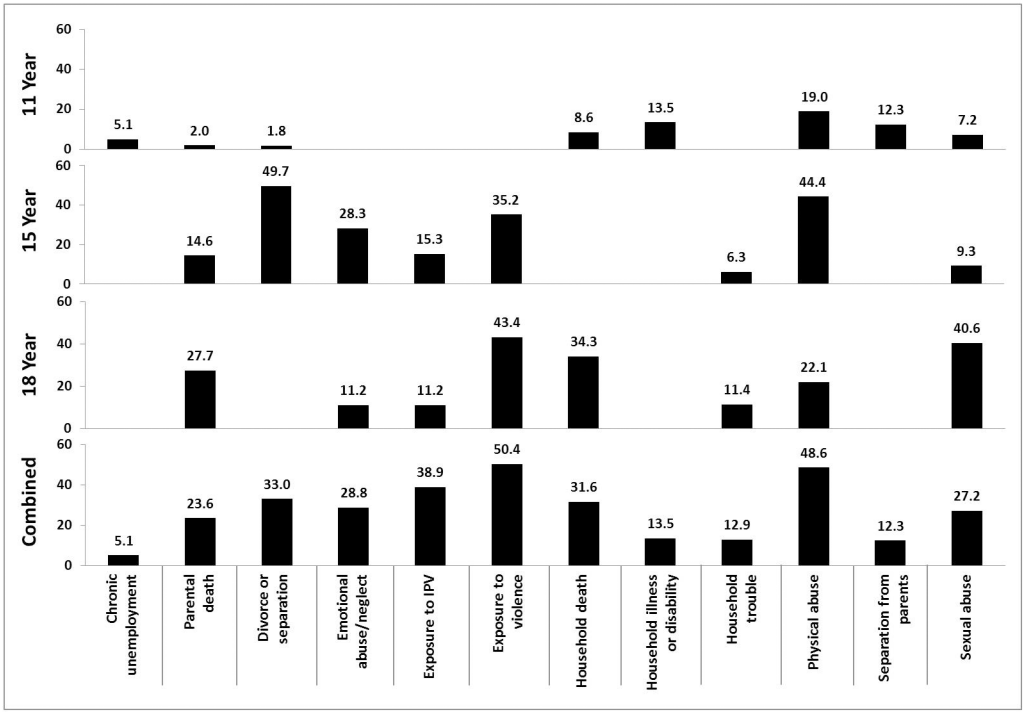

Fig 2. Prevalence (%) of ACEs reported by adolescents between 11 and 18 years of age.

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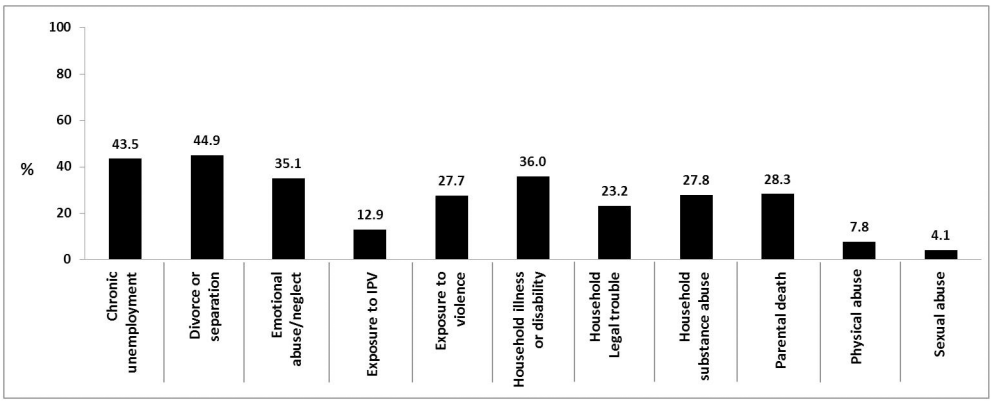

Fig 3. Prevalence (%) of ACEs retrospectively reported by young adults at age 21/22years.

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child separation from parents. Adolescent prospective reports of physical and sexual abuse, exposure to IPV and more general exposure to violence are much more prominent than prospective caregiver reports or retrospective young adult reports. Caregivers report a substantial social and material burden on the household in the early years of the child's life, with high levels of chronic unemployment, household death, illness/disability and substance abuse.

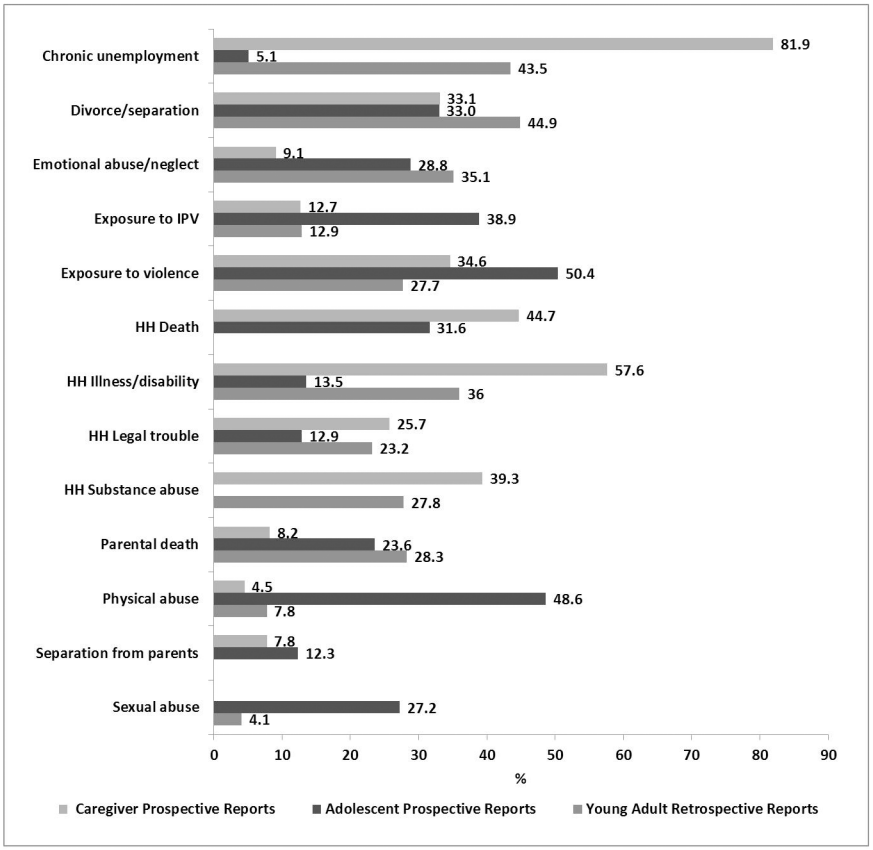

Fig 4. Prevalence (%) of ACEs by source and time point.

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Comparing young adult retrospective reports to caregiver and adolescent prospective reports about adverse experiences in childhood

Comparisons are made to determine the levels of agreement between prospective caregiver reports about childhood and prospective adolescent self-reports with retrospective reports by young adults. Levels of agreement between combined prospective caregiver and adolescent reports of ACEs compared to retrospective young adult reports of ACEs were also examined using Cohen's kappa (Table 2). The concordance rates reflect total agreement on an ACE whether reported present or absent at both time points or by both sources.

Across both combined caregiver and adolescent prospective reporting and separated caregiver and adolescent prospective reporting compared to retrospective young adult reporting there is significant agreement at *moderate* levels on parental death and household death (ranging from $k = .51$ $p < .0001$ to near *perfect agreement* at $k = .94$, $p < .0001$). There are *fair* levels of agreement for divorce/separation in each of the three comparisons, ranging from $k = .22$ to .34, $p < .0001$. Significant but *slight* levels of agreement are found for other ACEs across the comparisons.

Fig 5 illustrates the concordance rates by ACE when comparisons between accounts are seen side by side. For ACEs such as parental death, household substance abuse, household legal trouble, exposure to violence, emotional abuse/neglect, chronic unemployment, and divorce/separation the concordance between the three reports remains relatively consistent. The highest concordance rate (97.4%) is found between prospective adolescent reports and retrospective young adult reports on household death. High concordance is also seen between prospective caregiver reports and retrospective young adult reports on sexual and physical abuse and exposure to IPV (91.0%, 87.7% and 80.2%, respectively).

To understand how respondent source may play a role in reporting of ACEs, kappa values and concordance rates were calculated for ACEs that were reported on at the same time point for both caregiver and adolescent (at child age 11). Table 3 shows the levels of agreement for caregiver reported ACEs at age 11 and adolescent reported ACEs at year 11.

Despite very low kappa values, concordance rates for reported divorce/separation and child separation are high at 83.2% and 85.1%, respectively, with both the caregiver and the adolescent reporting low levels of divorce/separation and prolonged child separation. In comparison, concordance on chronic unemployment in the household is low at 18.7%. About 4.8% of adolescents report chronic unemployment in the household compared to 80.1% of caregivers at the same time.

Discussion

The aim of this study was to explore the levels of agreement between three accounts of reporting on ACEs - prospective caregiver reports on the period between 5 and 11 years in a child's life, prospective adolescent reports on the period between 11 and 18 years and retrospective young adult reports of experiences before the age of 18 years. In summary, we found that there was little overall agreement between combined or separate prospective accounts and retrospective accounts of childhood experiences, with a few exceptions that are described below.

The prevalence of reported ACEs

Overall the prevalence of individual reported ACEs was fairly high, naturally increasing by age – older children were more likely to report an ACE—with high rates of poverty reflected in the pervasiveness of unemployment at a rate of 81.9% at its highest, a finding echoed by an analysis of the prevalence of ACEs among children in a nationally representative US sample [77]. In

Table 2. Level of agreement between ratings for prospective caregiver and prospective adolescent reports compared to retrospective young adult reports of adverse childhood experiences.

ACE Variable	Cell frequencies				k	Conc. Rate (%)
	N1/N2	N1/Y2	Y1/N2	Y1/Y2		
Combined prospective caregiver and adolescent reporting (1) compared to retrospective young adult reporting (2)						
Physical abuse	683	36	772	86	.05**	48.8
Sexual abuse	941	34	517	29	.02	63.8
Emotional abuse/neglect	691	304	328	244	.12**	59.7
Divorce/separation	473	187	245	397	.34**	66.8
Parental death	1022	187	97	251	.52**	81.8
Exposure to IPV	733	90	624	112	.05*	54.2
Exposure to violence	373	93	753	337	.08**	45.6
HH Substance abuse	612	185	496	235	.09**	55.4
Chronic unemployment	141	60	726	604	.07**	48.7
HH Legal trouble	805	189	394	175	.13**	62.7
HH Illness & disability	370	191	618	346	.02	47.0
HH Death	724	0	471	624	.51**	74.1
Caregiver reporting (1) compared to retrospective young adult reporting (2)						
Physical abuse	1116	94	63	7	.02	87.7
Sexual abuse	1127	49	59	3	.01	91.0
Emotional abuse/neglect	764	399	69	65	.07**	64.0
Divorce/separation	510	288	179	265	.22**	62.4
Parental death	872	294	40	78	.21**	74.0
Exposure to IPV	1118	132	158	53	.15**	80.2
Exposure to violence	671	242	396	161	.03	56.6
HH Substance abuse	642	197	435	212	.11**	57.5
Chronic unemployment	111	48	725	599	.05**	47.9
HH Legal trouble	835	221	301	127	.09**	64.8
HH Illness & disability	367	190	590	332	.02	47.3
HH Death	509	244	443	229	.02	51.8
Adolescent reporting (1) compared to retrospective young adult reporting (2)						
Physical abuse	709	38	736	82	.05**	50.5
Sexual abuse	968	35	475	28	.01	66.1
Emotional abuse/neglect	724	340	271	196	.11**	60.1
Divorce/separation	527	288	104	237	.31**	66.1
Parental death	1011	179	75	214	.52**	82.8
Exposure to IPV	807	113	532	87	.02	58.1
Exposure to violence	564	150	551	271	.02*	54.4
Chronic unemployment	557	396	23	27	.03	58.2
HH Legal trouble	963	260	123	69	.11**	73.0
HH Illness & disability	584	279	79	55	.05*	64.1
HH Death	1148	0	47	624	.94**	97.4

N1/N2 = *No* ACE reported by both; N1/Y2 = *No* reported by 1, *Yes* reported by 2

*p < .05

**p < .0001

Y1/N2 = *Yes* reported by 1; *No* reported by 2; Y1/Y2 = *Yes* reported by both

Conc. rate = concordance rate (percentage of participants with Y1/Y2 and N1/N2)

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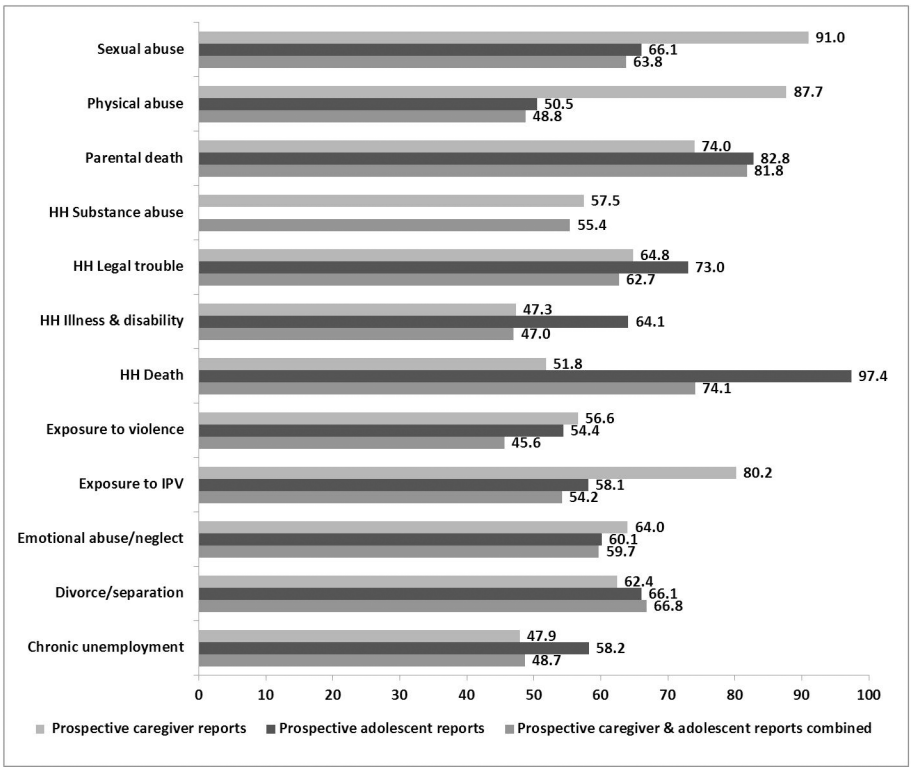

Fig 5. Concordance rates (%) for each ACE when prospective caregiver and prospective adolescent reports are compared to retrospective young adult reports, separately and combined.

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addition to the economic hardship, the authors report high rates of exposure to violence and divorce or separation, similar to the current study's findings. At a national level, 46% of children in the US [77] and 46.4% of participants in an English sample [78] report at least one ACE, compared to 92% in retrospective reporting and 98.9% in prospective reporting in this study. In other developing countries, similar high prevalence rates of reported ACEs are found. A retrospective study of young people in Russia estimated that 84.6% of respondents reported at least one ACE [79], and in a Brazilian birth cohort, 85% of adolescents reported at least a single ACE [80].

Table 3. Level of agreement between ratings for prospective caregiver reports (1) compared to prospective adolescent reports (2) of adverse childhood events at age 11.

ACE Variable	Cell frequencies				k	Conc. Rate (%)
	N1/N2	N1/Y2	Y1/N2	Y1/Y2		
Household illness/disability	549	79	370	63	.02*	57.7
Divorce or separation	877	14	163	3	.00*	83.2
Household unemployment	151	5	854	46	.01*	18.7
Household death	639	58	334	28	.01*	63.1
Child separation	888	116	47	9	.03*	85.1

N1/N2 = *No* ACE reported by both; N1/Y2 = *No* reported by 1, *Yes* reported by 2

*p < .05

Y1/N2 = *Yes* reported by 1, *No* reported by 2; Y1/Y2 = *Yes* reported by both

Conc. rate = concordance rate (percentage of participants with Y/Y and N/N)

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Depending on the type and measure of ACEs used, the timing of measurement and source, studies assessing the consistency of reporting of ACEs over time have found divergent results [51, 52, 54, 81]. There are substantial differences in the prevalence of reported ACEs across the three accounts assessed in this study. There are fairly consistent rates of reported ACEs across the three time points within the prospective caregiver reports, with less consistency in the prevalence of ACEs reported over the adolescent period. The prevalence of ACEs in adolescent reports tends to increase substantially around the 15-year period, particularly reports of physical and sexual abuse, and then decrease after the 18-year period. The prevalence of retrospectively reported ACEs by young adults is similar to that of prospective caregiver reports, particularly with regard to ACEs in the home environment such as chronic illness/disability, substance abuse, legal trouble, divorce/separation, and chronic unemployment in the household, and even extending to their own experiences of physical and sexual abuse.

Adolescents prospectively report much higher rates of exposure to violence, physical and sexual abuse than are reported retrospectively or by caregivers. As they enter secondary school and their environment expands to include peers, the range of experiences open to adolescents is greater which may explain these increases. In the adolescent reporting period, non-consensual petting and/or oral sex, in addition to penetration, are explicitly included in the operational definition of sexual abuse. As a developmental period, adolescence is also characterized by some level of egocentrism, perhaps making them acutely conscious of the events in their own lives and with a heightened perception of the severity of experiences. Research also suggests that memory is generally enhanced in adolescence and early adulthood [82], leaving adolescents less likely to forget negative experiences [83].

Levels of agreement across time

Overall, a combined prospective account of ACEs showed only *slight* levels of agreement with retrospective young adult reports. Seventy five percent of kappa values fell within the *slight* agreement range, 8% had *fair* agreement, and 17% had *moderate* agreement. When comparing prospective caregiver reports to retrospective young adult reports, 83% of kappa values represented *slight* agreement and 17% *fair* agreement. Prospective adolescent reports, compared to retrospective young adult reports, yielded 73% *slight* agreement; 9% *fair*, *moderate* and *near perfect* agreement, respectively. In all comparisons, the highest levels of agreement were found on household death and parental death. Yancura and colleagues found similar results noting that specific events such as deaths in the family and parental separation tended to have higher kappa values than other experiences [61]. The lowest levels of agreement are found in comparisons between prospective caregiver reports of ACEs and retrospective young adult reports of ACEs. One possible reason for this is that caregiver prospective reporting covered early to middle childhood, ending when the child was 11 years of age; the years of adolescence following this period are likely to include a larger range of experiences and greater opportunity for ACEs to occur.

Concordance rates of the different ACEs across the three comparisons mirrored agreement levels with the exceptions of physical and sexual abuse and exposure to IPV in the comparison between prospective caregiver reports and retrospective young adult reports. This could be as a result of the differences in the prevalence of reported physical and sexual abuse and exposure to IPV that increase in adolescence but is not retrospectively reported on in young adulthood. Despite the low kappa values, these high levels of concordance could be due to low endorsement rates or the rarity of the event compared to other ACEs. The concordance rates for each ACE when prospective caregiver and prospective adolescent reports are compared to retrospective young adult reports, separately and combined, are fairly consistent. This suggests that the nature of the ACE will influence how it is reported, over and above timing and source

issues. Apart from a few individual ACEs - sexual abuse, physical abuse and exposure to IPV in the prospective caregiver report and illness/disability and household death in the prospective adolescent report - the prospective accounts, separately or combined, do not appear to be highly concordant with the retrospective young adult account. This finding might have been anticipated, given that a study examining retrospective reports of childhood abuse just three years apart - at 18 and 21 years old - found substantial unreliability between reports [84].

Levels of agreement across source

Comparing prospective caregiver reports over the first 11 years of a child's life to retrospective self-reports in young adulthood is precarious in that the period of adolescence is unaccounted for. What may appear to be over-reporting in retrospective reports may simply represent events experienced during the adolescent period. But caregiver reports on the experiences in the early years of a child's life are also useful in understanding the impact of the early environment on later life, regardless of later recall, when confounding factors can be controlled for. In the first 11 years of the child's life caregivers report a large burden of care at the household level with high levels of substance abuse, legal trouble, chronic unemployment, chronic illness and disability, and family death. Children and adolescents may not always be aware of the level of adversity or the subsequent strain put on caregivers. In this analysis there were overall low levels of agreement between the different ACEs reported prospectively by caregivers when compared to young adults' retrospective reports, with the exception of physical and sexual abuse and exposure to IPV which showed high levels of concordance. A study on prospective mother reports and retrospective adolescent reports found similar results of moderate agreement when looking at physical abuse [85].

When comparing levels of agreement and concordance rates on the ACEs that were reported at age 11 by both the caregiver and the adolescent, the results similarly have low kappa values. There is high concordance between caregiver and child on divorce/separation and child separation. Both caregiver and child more or less agree on relatively low levels (absence) of divorce/separation in the home, and the presence of prolonged child separation. Findings in this study suggest that there is some concordance on specific ACEs whether or not they are reported as present or absent. One study found that, when comparing mother and offspring accounts of a range of adverse experiences, the two accounts tended to correspond when the adversity was absent [66]. The lowest concordance is found on chronic unemployment with adolescents reporting much lower levels of chronic unemployment in the household than caregivers at the same time. This raises issues around the type of ACEs different sources are able to report on; younger adolescents may be unaware of financial issues and the socio-economic status of the household in early childhood. Still, little research has been conducted on parents', particularly mothers', ability to provide a reliable account of their children's experiences in childhood. For a number of reasons parents may intentionally or unintentionally minimize adverse events in a child's life [86]. A study looking at mother and offspring retrospective reports of a range of childhood adversities found that mothers tend to under-report the frequency and severity of adverse events in their offspring's childhood [66]. In a similar study, Henry and colleagues found overall low levels of agreement between prospective mother reports collected in a birth cohort and retrospective reports collected when the respondents were 18 [87]. Agreement was higher for more objective experiences such as residential moves, but much lower for psychosocial and family processes. In a study with a larger gap between reports, Offer and colleagues compared adolescent self-reports and retrospective reports at approximate age 48 and found significant differences between what adults remember about adolescence and what was reported in adolescence [88].

Overall the findings in this study suggest unreliability when prospective reports from longitudinal data are compared to retrospective reports. While concluding that retrospective reports in adult life of adverse experiences in childhood are sufficiently valid, a review of the evidence cautions that the recall of experiences that are open to a wide degree of interpretation and rely substantially on judgment are less satisfactorily reported than those that are linked to serious abuse, neglect and conflict [51]. Issues around the design of assessments used to elicit information about sensitive childhood experiences also affect the reliability of reports. In two studies that assessed childhood abuse using different measures, fairly high rates of agreement were found [64, 65]; and through examining longitudinal data on 46 childhood experiences, Yancura and Aldwin conclude that retrospective reports may be reliable subject to well-designed assessments [61]. Examining the prospective prevalence of different reported ACEs across a number of time points shows variation in the experiences of children. It is difficult to know to what extent this variation reflects actual changes in circumstances or perceptions at different time periods. Prospective reporting may very much depend on current state or mood and retrospective reporting on disposition and life outcomes. Whether an experience becomes part of an individual's life story, to be reported on retrospectively, depends on a number of factors both at the time of the experience and in the years following it. Research suggests that these life stories are not shaped until the post-adolescent years [89], and may not be stable until middle age [90]. Another view is that retrospective and prospective approaches address fundamentally different questions. While a prospective design examines what proportion of children exposed to adverse experiences go on to develop negative outcomes, a retrospective design assesses what proportion of individuals presenting negative outcomes report exposure to adverse childhood experiences [68]. With this in mind, it is less an issue of which design is more valid or reliable, but which is better suited to the particular inquiry.

Study limitations

One limitation in the data is that questions probing adverse childhood experiences throughout the study were not phrased in exactly the same way at every wave of data collection. The ability to analyse agreement between sources of reporting was also limited given that there was overlap with caregiver and adolescent reports of ACEs on only a few variables at the 11 year time point.

Conclusion

As family structures change and new environments are open to children, their experiences and their understanding of these experiences are altered. Well-designed assessments of prospective and retrospective childhood experiences help to closely capture an account of what children experience over a given period. But our individual awareness, understanding and state during and after life events play a large role in what is recalled or reported. Alluding to a quote by Offer and colleagues [88], retrospective reports may be considered "existential reconstructions" of childhood, subject to a life story that fluctuates over the life course. The challenge is to identify which account of a life story has bearing on future outcomes, and to appreciate that the level of validity and reliability of an account depends, to some extent, on the purpose of inquiry.

Overall, South African children are exposed to a large number of different ACEs throughout childhood. Their retrospective recall of these experiences in young adulthood differs substantially from what is reported prospectively. In addition to more research on the reliability and validity of different reporting methods, multidisciplinary research is needed to explore how processes of memory formation and stress responses to physical and socioemotional

context, particularly in the adolescent brain, affect the perception and recall of experiences located in childhood. Both prospective and retrospective accounts of adverse childhood experiences should be understood within these parameters, and used to answer research questions appropriate to their function. Retrospective reports may be valuable in eliciting information about experiences that remain with us after certain periods of time while prospective reports may be critical for understanding the mechanisms that determine health and wellbeing outcomes based on contemporaneous experiences, regardless of later recall.

Supporting information

S1 Text. Survey questions used for data collection.
(PDF)

S1 Dataset. Minimal ACEs dataset.
(SAV)

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Appendix 2: Secondary analysis of retrospective and prospective reports of adverse childhood experiences and mental health in young adulthood: Filtered through recent stressors

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Research paper

Secondary analysis of retrospective and prospective reports of adverse childhood experiences and mental health in young adulthood: Filtered through recent stressors

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ABSTRACT

Background: Evidence has identified the detrimental effects that adverse childhood experiences (ACEs) have on outcomes across the life course. We assess associations between prospective and retrospective ACEs and mental health in young adulthood and the influence of recent stressors.
Methods: Secondary analysis of a sample of 1592 young adults from the Birth to Twenty Plus cohort, from 1990 to 2013, were assessed throughout their first 18 years for prospective ACEs. Retrospective ACEs and an assessment of mental health were collected at the 22–23-year data point.
Findings: Prospective physical and sexual abuse are associated with an increased risk of depression (OR 1·7 [95% CI 1·37–1·93, p = 0·034], and OR 1·8 [95% CI 1·27–2·07, p = 0·018], respectively). Retrospective emotional abuse/neglect is associated with increased anxiety (OR 1·8 [95% CI 1·32–2·36, p = 0·000]), depression (OR 1·6 [95% CI 1·08–2·25, p = 0·018]) and overall psychological distress (OR 1·6 [95% CI 1·18–2·17, p = 0·002]). Prospectively reporting four or more ACEs is associated with a twofold increase in risk for overall psychological distress (OR 2·2 [95% CI 1·58–3.12, p = 0·008]). Retrospectively reporting four or more ACEs is associated with increased likelihood of somatization (p = 0·004), anxiety (p = 0·002), depression (p = 0·021), and overall psychological distress (p = 0·005).
Interpretation: Both individual and combined retrospective and prospective ACEs are related to mental health in young adulthood. Recent stressors reinforce this relationship; the likelihood of those who report more ACEs experiencing psychological distress increases when adjusting for recent stressors.
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1. Introduction

A large body of research documents associations between adverse childhood experiences (ACEs) and health and well-being [1]. Risk factors for chronic disease including overweight and obesity [2,3], and smoking [4,5] have been linked to ACEs. The Kaiser ACE study found that as the number of exposures to ACEs increased, so did the prevalence and risk of, amongst others, alcoholism, use of illicit drugs, risky sexual behavior and having a history of a sexually transmitted infection [6]. Growing evidence suggests that ACEs are inter-related; [7] for example, childhood sexual abuse often occurs in the presence of other ACEs [8], emphasizing the need for ACEs to be assessed comprehensively.

Environmental, socioeconomic and behavioral exposures, whether independent or clustered together, can be compounded over time to manifest in an accumulation of risk, which can affect adult health and wellbeing either through cumulative damage over time or by the biological embedding of adversities during sensitive developmental periods [9,10]. The value of the ACE score, the total number of ACEs to which an individual reports having been exposed, lies in the ability to examine the cumulative impacts of ACEs on later life outcomes. The evidence describes the relationship between the extent of ACEs and social and health problems as one that predicts the risk to increase in a strong and graded manner as the number and severity of ACEs increase. Growing evidence shows that some ACEs – and some combinations – have a more deleterious effect on health and well-being than others [11], and may possibly have differential effects on different outcomes. For example, one study linked a cluster of ACEs related to abuse and neglect to higher severity bipolar

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Research in Context

Evidence before this study

Experiences of adversity in childhood have been linked to increased risk of poor mental health outcomes in later life, with less evidence in the young adult population. Results from previous analyses show the prevalence of reported adverse childhood experiences (ACEs) vary when assessed prospectively and retrospectively in the same sample, however the evidence in LMICs is scarce. Adult stress, independent of early adversity, has been linked to mental health problems, but is also hypothesized to act in conjunction with histories of adversity to either sensitize individuals to future stressors, disrupt coping strategies or aggravate negative mental health outcomes.

Added value of this study

The findings of this study indicate that the timing, type and number of reported ACEs work together to impact on mental health outcomes in young adulthood. Both prospective and retrospective reporting of four or more ACEs are associated with poor mental health, even though the prevalence of retrospective reports of individual ACEs decreases over time. When adjusted for the number of recent stressors, the likelihood of overall psychological distress increases as the number of ACEs increases.

Implication of all the available evidence

While the concept of adverse childhood experiences constitutes a range of negative exposures for children (1) some are more deleterious on mental health in young adulthood, independent of others, (2) the cumulative risk of ACEs should not be ignored since poor mental health in young adulthood is also associated with the total number of ACEs reported, and (3) females report exposure to a similar number of adverse childhood experiences prospectively and fewer retrospectively than their male counterparts but are at twice the risk of poor mental health.

disorder and schizophrenia, compared to a cluster of social support-related ACEs [12]. In another study on the clustering of individual ACEs, a child maltreatment and peer victimization group was associated with double the odds of self-rated poor physical health and three times the odds of self-rated poor mental health, compared to a household challenges grouping which was linked to an almost 3-fold chance of reporting poor physical health and six-times odds of reporting poor mental health [13].

In addition to the clustering and relative weight of certain ACEs, the method of data collection – essentially the timing of reporting – has been explored. Studies have found low to moderate agreement between prospective and retrospective ACEs, depending on the type of ACE [14,15], and have also found differential associations with outcomes. One such study found that while prospective and retrospective reports showed associations with outcomes in midlife, retrospectively reported ACEs showed stronger associations with outcomes that were subjectively assessed compared to those objectively assessed [15]. Further complexity abounds when the nature of prospective reports are examined; while these are taken to be near-contemporaneous accounts of events, prospective data is often still recalled or reported by participants, or in the case of young children – caregivers. Prospective accounts such as court records of abuse or substantiated cases of adversity are considered objective but are challenging to integrate into research for a number of reasons; they also represent only a proportion of real cases – those considered serious enough to go through the child protection system, and those that are actually reported [16]. However, emerging evidence points to the association of retrospective reports with negative outcomes, including psychopathology, even when there are inconsistencies with objective evidence of adversity [15,17]. Moreover, recent life stress has been hypothesized to play some role in the relationship between early adversity and adult outcomes. Theories put forward include the dysregulation of stress response systems which result in maladaptive responses to subsequent stress or the increase in risk for future adversity based on exposure to adversity in childhood [18,19]. Findings from the Birth to Twenty Plus cohort show that high levels of adult stress significantly increased the likelihood of psychological distress for those with high levels of ACEs, and posit a possible mediation effect between ACEs and psychological distress [20]. A number of studies have linked ACEs to poor mental health in adulthood [21-25]. The long-term effects of ACEs on mental health during the early adult years in low-middle-income settings have been understudied and where they have, most studies include clinical or cross-sectional samples [26]. Studies that have been conducted confirm the relationship between exposure to ACEs and poor adult mental health [27]. The aim of this study is to assess the associations of prospectively and retrospectively reported accounts of ACEs to the mental health of a young adult sample from a peri-urban, historically disadvantaged South African context. In addition, this study will explore potential mediating or moderating effects of recent stressors on the relationship between ACEs and mental health outcomes. The study will contribute to the ACEs literature by exploring how different approaches to ACEs measurement – single, cumulative and prospective versus retrospective, can be associated with mental health outcomes in a young adult sample. Clarity on the timing, type and number of ACEs that are linked to persistent negative outcomes is critical for the development of appropriate interventions, particularly in contexts like South Africa where there exists a large gap between the burden of mental health problems and the resources available to address it [28].

2. Methods

2.1. Study design and participants

The Birth to Twenty Plus study (BT20+) is a South African birth cohort of 3273 singleton children born to mothers who were residents of Soweto-Johannesburg in a 7-week period of enrolment in 1990. The study is unique in that it is the largest and longest running study of child and adolescent health and development in Africa. Current participants are 30 years old, have been assessed up to 22 times and, since 2005 when the first participant birth occurred, includes the 3rd generation of the cohort. A detailed description of the study, its birth cohort and participants is published elsewhere [29]. This study uses data from birth to age 22–23-years old for prospective and retrospective reports of ACEs and covers the period between 1990 and 2013. A total of 1636 participants were surveyed at the 22–23-year wave and a sample of 1592 participants from this group that had both retrospective and prospective reports of ACEs was included in this analysis. Ethical clearance was obtained from the Witwatersrand University Committee for Research on Human Subjects (protocol number: M140726). All participants and/or their caregivers gave informed written consent for the data reported.

2.2. Procedures

2.2.1. Adverse childhood experiences and recent stressors

Adverse childhood experiences have been defined as physical abuse, sexual abuse, emotional abuse and/or neglect, child separation, divorce or parent separation, parent death, exposure to violence,

exposure to intimate partner violence (IPV), chronic unemployment, household substance abuse, household legal trouble, household serious illness or disability, and household death. The ACEs survey questions are included in Supplementary Table A. For prospective reports, caregivers were asked to report on their children at participant ages 5, 7 and 11, and participants provided self-reports at ages 11, 15 and 18. A participant was recorded as having experienced a particular ACE if there was a positive response at any one of these time points. For the retrospective report, participants were asked at the 22–23-year wave to indicate if they had experienced each of the ACEs during the first 18 years of their life. A full detailed account of individual ACEs reported at each of the 7 time points, as well as an analysis of the level of agreement between sources and timing, has been published [14]. In summary, that analysis found the reports of prospective and retrospective ACEs, used in this study, had little overall agreement; 80% of the kappa values were below the moderate agreement cut-off of k = 0·41. The highest levels of agreement were between reports on parental death (k = 0·52) and household death (k = 0·51). Reporting on early life ACEs by caregivers (at ages 5, 7 and 11) showed the greatest concordance with retrospective reports of ACEs on sexual abuse (91·0% agreement), physical abuse (87·7% agreement), and exposure to intimate partner violence (80·2% agreement) [14].

For the purposes of this paper, we conceptualise the ACEs directly impacting an individual – physical, sexual, and emotional abuse – as proximal ACEs, and those occurring in their environment – exposure to IPV, household illness, chronic unemployment – as distal ACEs. For ease of reading, retrospectively reported ACEs may be referred to as 'retrospective ACEs' and vice versa; similarly, for individual ACEs we may use the shorthand 'prospective physical abuse' rather than 'prospectively reported physical abuse' but the method of data collection for all ACEs is either self-reported or parent-reported (in the case of children under the age of 7 years).

An assessment of recent stressors, adapted from the Township Life Event Scale [30], was added to the analysis. Participants were asked at the 22–23-year data collection wave to indicate if they had experienced any of 9 negative life events – considered stressors – in the past 6 months. The 9 events included violence in the household (1), workplace (2) or community (3), household illness (4), disability (5) or death (6) in the family, household substance abuse (7), alienation from family (8), and legal trouble (9). Full questions are available in Supplementary Table A.

2.3. Mental health outcomes

Young adult mental health was assessed using the self-reported GHQ-28 which comprises 4 sub-scales of 7 items each probing for somatic symptoms, anxiety and insomnia, social dysfunction, and major depression. The 28 items are scored in a binary 0011 method. Higher scores on the GHQ-28 represent higher levels of psychological distress. The GHQ-28 is used in epidemiological studies as a screening for minor psychiatric morbidity caseness (clinically significant anxiety and/or depression). Any score above 4 on a subscale and above 23 on the total scale indicates the presence of distress or a positive diagnostic [31].

2.4. Statistical analysis

Data was analyzed using STATA statistical software version 13·0. The ACEs data was transformed into a retrospective and a prospective categorical score for each participant as follows: 0= 'no reported ACEs', 1= 'one reported ACE', 2= 'two reported ACEs', 3= 'three reported ACEs' and 4= 'four or more reported ACEs'. In parts of the analyses outcomes are compared between 'less than four' and 'four or more' reported ACEs. There are currently no guidelines on the ACEs scoring in the available literature but some studies do point to the 'four or more' cut-off functioning as a threshold level, with noticeable deviations in a range of outcomes at that mark [6,32].

The four mental health outcomes, somatization, anxiety, social dysfunction, and depression were transformed into categorical data and the co-occurrence of psychological distress with reports of ACEs was evaluated using the chi-square statistic. Unadjusted effects of each individual ACE, followed by each composite measure of ACEs, separately for prospective and retrospective ACEs, were tested for effects on somatization, anxiety, social dysfunction, depression and GHQ total. Five adjusted logistic regression models were fitted including significant predictors from the unadjusted models, controlling for sex, socio-economic status, maternal education and recent stressors, to estimate the association between the ACE scores and each outcome. Odds ratios and 95% confidence intervals were calculated separately for each outcome. In the fully adjusted models, retrospective and prospective ACEs are entered in the same model together with the selected covariates, therefore the ORs for prospective ACEs indicate the contribution of prospective ACEs independently from retrospective ACEs and vice versa. Factorial analysis of variance was used to test for the unique contribution of prospective and retrospective reports of ACEs, as well as any interactions between them, to the variance in each mental health outcome.

Regression analysis was used to test for mediation and moderation effects of recent stressors on mental health outcomes. Factorial analysis of variance tested for interaction effects between retrospectively and prospectively reported ACEs and recent stressors on psychological distress. These analyses yielded no significant results and the recent stressors were subsequently added to the regression models as a covariate.

2.5. Role of the funding source

The funder of the study had no role in the study design, data collection, data analysis, and data interpretation, or writing of the report. All authors had full access to the data and accept final responsibility to submit for publication. Access to the data is available to all authors for as long as they are part of the study team. Authors are permitted to keep their own copy of a dataset specific to a publication ad infinitum.

3. Results

3.1. Sample and data description

Of the initial 3273 participants recruited in 1990, 1636 were surveyed at the 22–23-year wave in 2017, representing a loss to follow-up of 50%. ACEs data was available for 1592 of the 1636 participants surveyed in 2013, the remaining 42 participants were not included in this analysis. A description of sample demographics at recruitment and at the 22–23-year wave, by sex, is shown in Table 1.

ACE scores were computed for each participant who had data for at least 10 of the 13 ACEs; those with fewer than 10 – or 3 or more missing data points – were excluded from the analytic dataset. For prospective data, missing data was imputed from previous and subsequent waves of data to compose comprehensive accounts. In the retrospective data, all variables except for parental divorce (17%) had less than 10% missing values. The analysis was restricted to cases with data on the exposures, only cases with data for both prospective and retrospective ACEs were included. Missing data ranged from 1·07% to 3·52% on outcome variables, and between 0·19% and 7·91% on the covariates (Supplementary Table B). The distribution of ACEs among cases with data was not substantially different from those cases without data on a specific variable, and significant differences are due to the small number of missing cases (Supplementary Table C). The largest proportions of missing data were among covariates

Table 1
Demographic profile of sample at baseline and at 22–23-year wave, by sex.

Timepoint	Baseline[a]			22–23-year wave[b]		
	Total N (%)	Male N (%)	Female N (%)	Total N (%)	Male N (%)	Female N (%)
Marital status						
Married or cohabitating	558 (35·3)	282 (37·1)	276 (33·6)	786 (50·2)	340 (45·2)	446 (54·9)
Single or separated	1024 (64·7)	479 (62·9)	545 (66·4)	779 (49·8)	412 (54·8)	367 (45·1)
Education						
No formal education	193 (13·1)	97 (13·8)	96 (12·5)	0 (0)	0 (0)	0 (0)
Primary school	687 (46·5)	337 (47·8)	350 (45·4)	3 (0·2)	1 (0·2)	2 (0·3)
Secondary school	492 (33·3)	221 (31·4)	271 (35·2)	942 (70·0)	398 (69·6)	544 (70·4)
Post-school education	104 (7·1)	50 (7·1)	54 (7·0)	400 (29·7)	173 (30·2)	227 (29·4)
Socioeconomic status[a]						
Quintile 1	225 (15·4)	114 (16·2)	111 (14·5)	505 (32·8)	250 (33·7)	255 (31·8)
Quintile 2	269 (18·4)	130 (18·5)	271 (35·5)	242 (16·7)	117 (15·8)	125 (15·6)
Quintile 3	511 (34·9)	240 (34·2)	271 (35·5)	309 (20·0)	162 (21·9)	147 (18·4)
Quintile 4	297 (20·3)	148 (21·1)	149 (19·5)	272 (17·6)	118 (15·9)	154 (19·2)
Quintile 5	164 (11·2)	70 (10·0)	94 (12·3)	214 (13·9)	94 (12·7)	120 (15·0)
Adverse childhood experiences						
0	294 (23·1)	137 (22·9)	157 (23·2)	139 (8·7)	61 (43·9)	78 (56·1)
1	469 (36·8)	214 (35·8)	255 (37·7)	277 (17·4)	132 (47·7)	145 (52·3)
2	188 (14·7)	95 (15·9)	93 (13·7)	293 (18·4)	113 (38·6)	179 (61·4)
3	122 (9·6)	58 (9·7)	64 (9·5)	279 (17·6)	138 (49·5)	140 (50·5)
≥4	202 (15·8)	94 (15·7)	108 (16·0)	604 (38·0)	320 (53·0)	283 (47·0)

[a] Measure of maternal or household characteristics.
[b] Measure of the participant's characteristics.

Table 2
Prevalence of ACEs by report type and sex.

Source of report	Prospective report			Retrospective report		
	Total N (%)	Male N (%)	Female N (%)	Total N (%)	Male N (%)	Female N (%)
Adverse childhood experiences						
Physical abuse	880 (55·3)	457 (51·9)	423 (48·1)	118 (7·4)	67 (56·8)	51 (43·2)
Sexual abuse	613 (38·5)	296 (48·3)	317 (51·7)	63 (4·0)	22 (34·9)	40 (65·1)
Emotional abuse/neglect	577 (36·2)	282 (48·9)	294 (51·1)	552 (34·7)	278 (50·4)	272 (49·6)
Child separation	244 (15·3)	105 (43·0)	139 (57·0)	–	–	–
Divorce/separation	816 (51·3)	382 (46·8)	434 (53·2)	593 (37·3)	283 (47·7)	309 (52·3)
Parental death	357 (22·4)	182 (51·0)	173 (49·0)	443 (27·9)	230 (51·9)	212 (48·1)
Exposure to violence	1114 (70·0)	591 (53·0)	522 (47·0)	431 (27·1)	246 (57·1)*	184 (42·9)*
Exposure to IPV	750 (47·1)	422 (56·3)*	326 (43·7)*	202 (12·7)	93 (46·0)	108 (54·0)
Chronic unemployment	1346 (84·5)	645 (47·9)	701 (52·1)	684 (43·0)	346 (50·6)	337 (49·4)
Household substance abuse	740 (46·5)	346 (46·8)	394 (53·2)	438 (27·6)	235 (53·7)	202 (46·3)
Household legal trouble	579 (36·4)	325 (56·1)*	254 (43·9)*	364 (22·9)	202 (55·5)	162 (44·5)
Household illness/disability	984 (61·8)	475 (48·3)	509 (51·7)	553 (34·8)	258 (46·7)	294 (53·3)
Household death	971 (61·0)	458 (47·2)	510 (52·8)	396 (24·9)	193 (48·7)	200 (51·3)
ACE score						
0	8 (0·5)	3 (37·5)	5 (62·5)	139 (8·7)	61 (43·9)	78 (56·1)
1	26 (1·6)	12 (46·2)	14 (53·8)	277 (17·4)	132 (47·7)	145 (52·3)
2	46 (2·9)	13 (28·3)*	31 (71·7)*	293 (18·4)	113 (38·6)*	179 (61·4)*
3	120 (7·5)	55 (45·8)	65 (54·2)	279 (17·6)	138 (49·5)	140 (50·5)
≥4	1392 (87·4)	681 (48·9)	710 (51·1)	604 (38·0)	320 (53·0)	283 (47·0)
Total	1592 (100·0)	764 (48)	825 (52)	1589 (100·0)	764 (48·1)	825 (51·9)

*$p<.001$ – significant differences between males and females.

(up to 7·91%) and these cases were dropped through listwise deletion during the regression analyses. Given the relatively small proportions of missing data, and the comprehensiveness of ACE data, no further handling of missing data was done and all analyses assumes data are missing at random, which the authors concede is a limitation.

3.2. Prevalence of ACEs

Table 2 shows the frequency of ACEs by source of report and sex. Exposure to individual ACEs is summed to create an ACE score. Changes in the prevalence of ACEs by report (prospective versus retrospective) and source (self- versus parent-) in this cohort has been explored in greater detail in a previous publication [14] and are summarized in the methods section. The proportion of participants who report experiencing four or more ACEs drops by more than half, from 87·4% to 38·0%, when reported retrospectively compared with prospective reporting. The prevalence of all ACEs decreases from prospective to retrospective reporting, with the exception of reports of parental death which increases from 22·4% to 27·9%. The greatest decreases are in reports of physical and sexual abuse (87% and 90% decrease, respectively), exposure to violence inside and outside of the household (73% and 61% decrease, respectively), and chronic unemployment in the household (49% decrease). Reports of emotional abuse/neglect are much the same regardless of when it is reported, with 36·2% prospectively and 34·7% retrospectively. Overall, individuals tend to report fewer ACEs retrospectively than they do prospectively, with 12·5% of participants reporting fewer than four ACEs prospectively compared to 62·0% retrospectively.

Table 3
ACE profiles by demographic variables.

	None N (%)	One N (%)	Two N (%)	Three N (%)	Four or more N (%)	Total N (%)
Prospective Report Total	8 (0·5)	26 (1·6)	46 (2·9)	120 (7·5)	1392 (87·4)	1592 (100·0)
Maternal marital status						
Married or cohabitating	5 (71·4)	10 (40·0)	19 (43·2)	55 (45·8)	469 (33·8)*	558 (35·3)
Single or separated	2 (28·6)	15 (60·0)	25 (56·8)	65 (54·2)	917 (66·2)*	1024 (64·7)
Maternal education						
No formal education	0 (0·0)	2 (8·0)	3 (7·5)	16 (14·4)	172 (13·3)	193 (13·1)
Primary school	0 (0·0)*	5 (20·0)*	19 (47·5)	52 (46·8)	611 (46·5)	687 (46·5)
Secondary school	5 (71·4)*	16 (64·0)*	14 (35·0)	32 (28·8)	425 (32·9)	492 (33·3)
Post-school education	2 (28·6)*	2 (8·0)	4 (10·0)	11 (9·9)	85 (6·6)	104 (7·1)
Sex						
Male	3 (37·5)	12 (46·2)	13 (29·5)*	55 (45·8)	681 (49·0)	764 (48·1)
Female	5 (62·5)	14 (53·8)	31 (70·5)*	65 (54·2)	710 (51·0)	825 (51·9)
Socioeconomic status[a]						
Quintile 1	0 (0·0)	4 (18·2)	6 (15·4)	20 (17·5)	192 (15·2)	225 (15·45)
Quintile 2	2 (28·6)	5 (22·7)	5 (12·8)	14 (12·3)	243 (18·9)	269 (18·4)
Quintile 3	1 (14·3)	3 (13·6)	17 (43·6)	38 (33·3)	452 (35·2)	511 (34·9)
Quintile 4	3 (42·9)	6 (27·3)	5 (12·8)	22 (19·3)	261 (20·3)	297 (20·3)
Quintile 5	1 (14·3)	4 (18·2)	6 (15·4)	20 (17·5)*	133 (10·4)*	164 (11·2)
Retrospective Report Total	139 (8·7)	277 (17·4)	293 (18·4)	279 (17·5)	604 (37·9)	1592 (100·0)
Maternal marital status						
Married or cohabitating	59 (43·1)	116 (41·9)*	100 (34·6)	95 (34·2)	188 (31·3)*	558 (35·3)
Single or separated	78 (56·9)	161 (58·1)	189 (65·4)	183 (65·8)	413 (68·7*)	1024 (64·7)
Maternal education						
No formal education	15 (11·8)	37 (14·2)	29 (10·6)	385 (14·6)	74 (13·3)	193 (13·1)
Primary school	42 (33·1)*	111 (42·7)	127 (46·5)	118 (45·4)	289 (52·0)*	687 (46·5)
Secondary school	55 (43·3)*	90 (34·6)	103 (37·7)	86 (33·1)	158 (28·4)*	492 (33·3)
Post-school education	15 (11·8)*	22 (8·5)	14 (5·1)	18 (6·9)	35 (6·3)	104 (7·1)
Sex						
Male	61 (43·9)	132 (47·7)	113 (38·7)*	138 (49·6)	320 (53·1)*	764 (48·1)
Female	78 (56·1)	145 (52·3)	179 (61·3)*	140 (50·4)	283 (46·9)*	825 (51·9)
Socioeconomic status[a]						
Quintile 1	14 (11·1)	37 (14·3)	31 (11·3)	41 (15·9)	102 (18·6)*	225 (15·4)
Quintile 2	23 (18·3)	39 (15·1)	53 (19·3)	48 (18·6)	106 (19·3)	269 (18·4)
Quintile 3	39 (31·0)	93 (36·0)	95 (24·5)	89 (34·5)	195 (35·5)	511 (34·96)
Quintile 4	32 (25·4)	56 (21·7)	62 (22·5)	43 (16·7)	104 (18·9)]	297 (20·3)
Quintile 5	18 (14·3)	33 (12·8)	34 (12·4)	37 (14·3)	42 (7·7)*	164 (11·2)

[a]in quintiles with increasing SES.
*$p<.05$ – significant differences between ACE scores.

Categories for ACEs found in the literature were compared across socio-demographic variables (Table 3). Significant differences are indicated by asterisk. In both prospective and retrospective reporting of ACEs, a significantly higher proportion of children living in households with single or separated parents report four or more ACEs (p = 0·14). Similarly, higher maternal education appears to be associated with fewer reported ACEs both retrospectively and prospectively (p = 0·006). Males and females tend to report similar numbers of ACEs prospectively. However, the number of males who report four or more ACEs retrospectively is significantly higher (p = 0·001). More participants in higher socio-economic quintiles report fewer ACEs both retrospectively and prospectively.

3.3. Associations between ACEs and mental health outcomes

Table 4 shows the distribution of mental health outcomes for ACEs reported prospectively and retrospectively, categorized as 'less than four' or 'four or more'. Given patterns in the literature associating adversity in childhood with poor mental health [12,13], it is expected that a greater proportion of respondents who report four or more ACEs will present with psychological distress. Using prospective reports of ACEs there appears to be little significance between reported ACEs and psychological distress (somatization, p = 0·465; anxiety, p = 0·263; social dysfunction, p = 0·522; depression, p = 0·050; GHQ total, p = 0·273). Using the retrospective reports, there are significant differences in the expression of psychological distress between respondents who report less than four or four or more ACEs on all mental health outcomes (p = 0·000), apart from social dysfunction (p = 0·360).

Adding both reports into one model per outcome, we explore the relative contribution of prospective and retrospective reports of ACEs to the variance in each outcome (Supplementary Table D). Significant models were found for somatization [F(3, 1570) = 7·18, p = 0·000], anxiety [F(3, 1570) = 25·31, p = 0·000], depression [F(3, 1570) = 26·13, p = 0·000], and total GHQ [F(3, 1532) = 20·73, p = 0·000], but not for social dysfunction [F(3, 1571) = 0·45, p = 0·7160]. For somatization, only retrospective ACEs have a significant main effect (p = 0·000) with no interaction effect. Similarly, for anxiety and total GHQ, retrospective ACEs are the only main effect (p = 0·000) with no interaction effect. There are no significant main or interaction effects for social dysfunction (p = 0·518 for prospective ACEs, p = 0·503 for retrospective ACEs, and p = 0·736 for their interaction). For depression, both prospective and retrospective ACEs have significant main effects at the p = 0·000 level, slightly stronger for retrospective ACEs (eta^2=0·0266) compared to prospective ACEs (eta^2=0·0122), and a significant interaction effect (p=0·0440). Overall, the results indicate that composite measures of retrospective ACEs are associated with somatization, anxiety and the total GHQ; while both prospective and retrospective ACEs contribute to depression. In addition, reporting above the mean (2·5) prospective ACEs and more than four retrospective ACEs is associated with increased scores on depression.

Table 4
Distribution of mental health symptoms for reported ACES.

Mental health outcome	Prospective report (%)			Retrospective report (%)		
	Less than 4	Four or more	Sig.	Less than 4	Four or more	Sig.
Somatization	125 (63·8)	887 (64·4)	·465	658 (67·7)	354 (58·8)	·000
Below cut-off	71 (36·2)	491 (35·6)		314 (32·3)	248 (41·2)	
Above cut-off						
Anxiety	113 (57·7)	831 (60·3)	·263	650 (66·9)	294 (48·8)	·000
Below cut-off	83 (42·3)	547 (39·7)		322 (33·1)	308 (51·2)	
Above cut-off						
Social dysfunction	82 (41·8)	576 (41·8)	·522	410 (42·2)	248 (41·1)	·360
Below cut-off	114 (58·2)	803 (58·2)		562 (57·8)	355 (58·9)	
Above cut-off						
Depression	174 (88·8)	1160 (84·2)	·055	865 (89·0)	469 (77·9)	·000
Below cut-off	22 (11·2)	218 (15·8)		107 (11·0)	133 (22·1)	
Above cut-off						
GHQ Total	145 (75·5)	983 (73·1)	·273	755 (78·8)	373 (64·5)	·000
Below cut-off	47 (24·5)	361 (26·9)		203 (21·2)	205 (35·5)	
Above cut-off						

Figures 1, 2, 3, 4 and 5 illustrate the odds ratios for each adjusted model. Results from the unadjusted and adjusted stepwise regressions are included in the supplement as Supplementary Tables E and F.

Irrespective of ACEs, females report significantly higher levels of poor mental health (anxiety: OR 2·4 [95% CI 1·84–3·01, p = 0·000]; somatization: OR 2·2 [95% CI 1·72–2·76, p = 0·000]; social dysfunction: OR 1·5 [95% CI 1·22–1·88, p = 0·000]; depression: OR 2·8 [95% CI 1·99–3·89, p = 0·000]; total GHQ: OR 2·6 [95% CI 2·02–3·43, p = 0·000]). No other socio-demographic variables included here significantly account for variations in mental health outcomes; apart from in the social dysfunction subscale, where *only* socio-demographic variables contribute to increased risk for greater social dysfunction.

A number of individual ACEs are associated with an increased risk for psychological distress. Retrospective emotional abuse/neglect is associated with increased anxiety (OR 1·8 [95% CI 1·32–2·36,

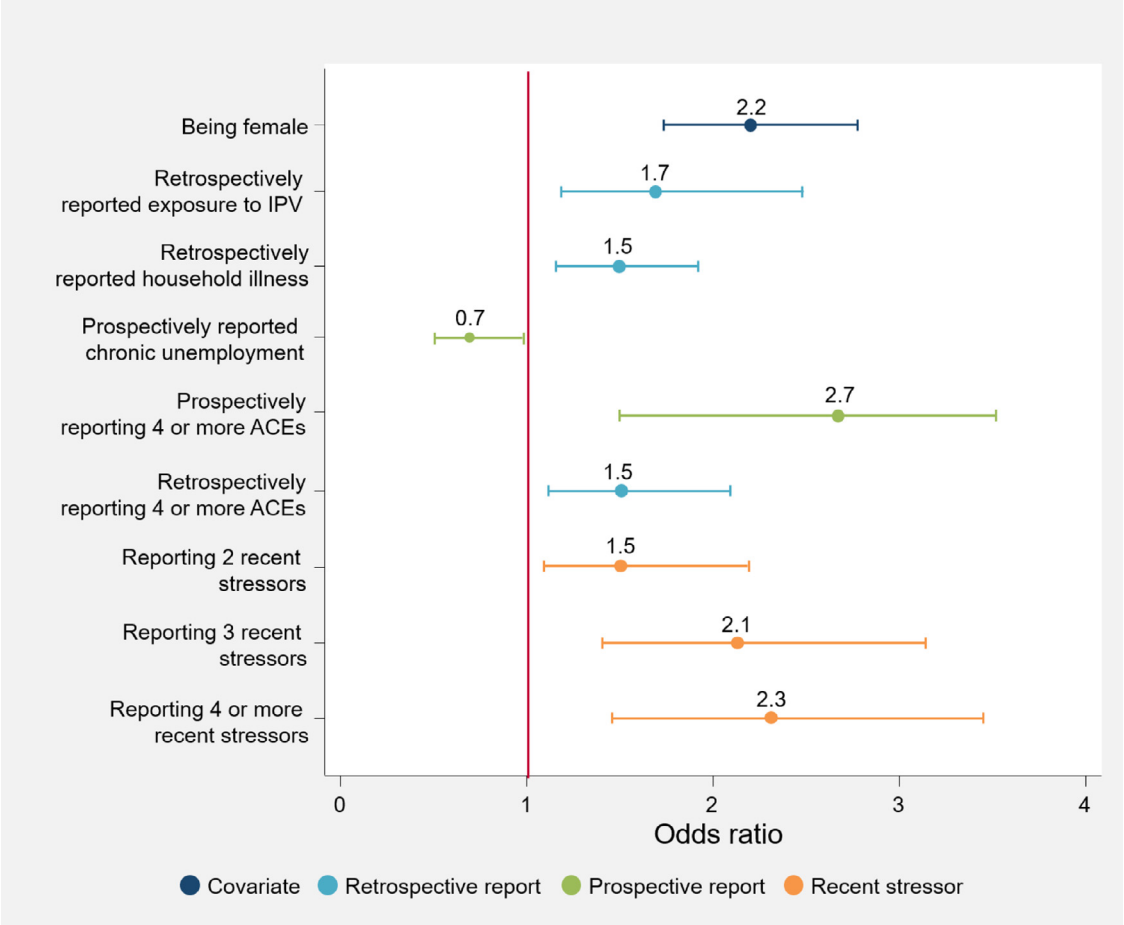

Fig. 1. Adjusted effects of reported ACEs and covariates on somatization
This figure shows the fold-increase in the odds of experiencing levels of somatization indicating psychological distress given reports of retrospective and prospective ACEs and additional covariates, including recent stressors. Odds ratios (ORs) and their respective confidence intervals for the adjusted model are available in Supplementary Table F.

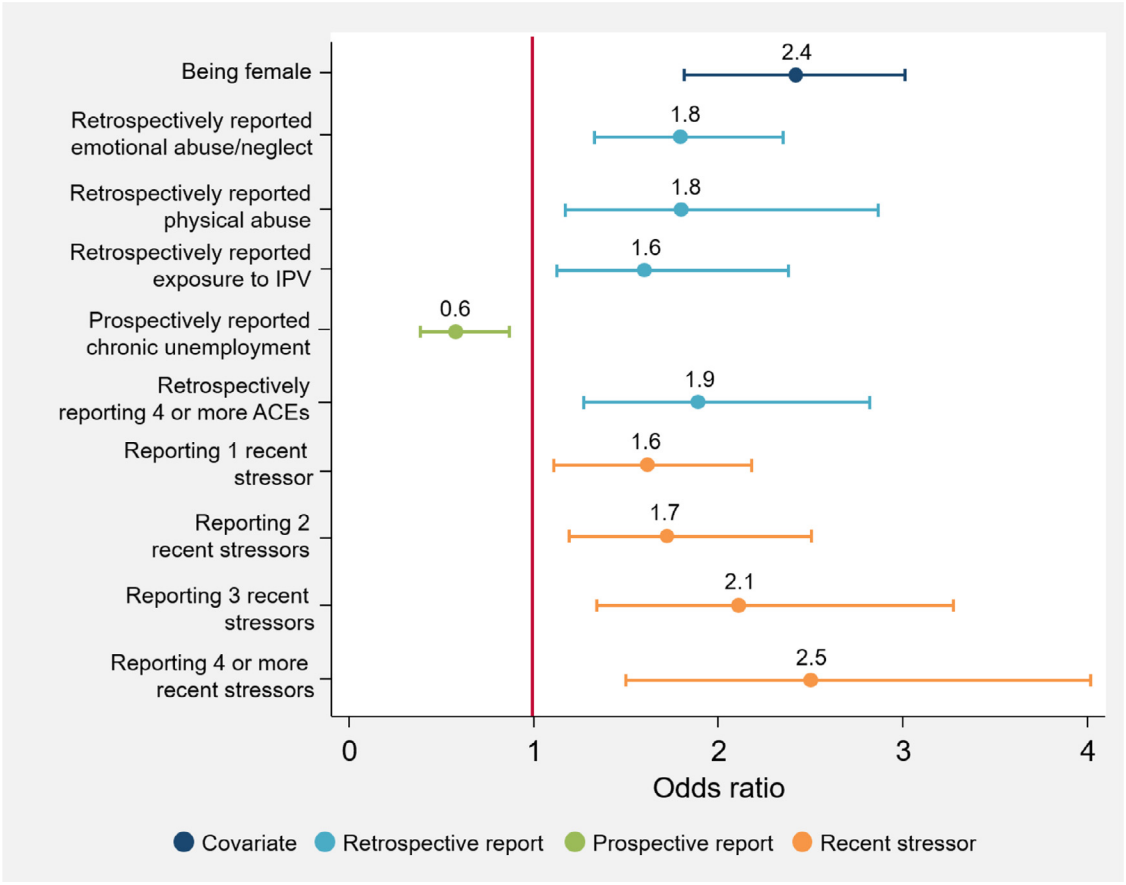

Fig. 2. Adjusted effects of reported ACEs and covariates on anxiety
This figure shows the fold-increase in the odds of experiencing levels of anxiety indicating psychological distress given reports of retrospective and prospective ACEs and additional covariates, including recent stressors. Odds ratios (ORs) and their respective confidence intervals for the adjusted model are available in Supplementary Table F.

p = 0·000]), depression (OR 1·6 [95% CI 1·08–2·25, p = 0·018]) and psychological distress in general (OR 1·6 [95% CI 1·18–2·17, p = 0·002]), while prospective emotional abuse/neglect is linked to increased psychological distress (OR 1·3 [95% CI 1·04–1·63, p = 0·034]). Retrospective exposure to severe household illness/disability is associated with increased somatization (OR 1·5 [95% CI 1·14–1·92, p = 0·004]); and retrospective exposure to IPV is associated with increased somatization (OR 1·7 [95% CI 1·19–2·46, p = 0·002]) and anxiety (OR 1·6 [95% CI 1·12–2·37, p = 0·010]). Both prospective physical and sexual abuse are associated with an increased risk of depression (OR 1·7 [95% CI 1·37–1·93, p = 0·034], and OR 1·8 [95% CI 1·27–2·07, p = 0·018], respectively). Prospective chronic household unemployment is associated with a decreased risk of somatization (OR 0·7 [95% CI 0·50–·99, p = 0·048]) and anxiety (OR 0·6 [95% CI 0·45–·91, p = 0·013]).

When looking at cumulative ACEs retrospectively, the greater the number of reported ACEs, the greater the risk for anxiety (OR 1·9 [95% CI 1·27–2·83, p = 0·002]), somatization (OR 1·5 [95% CI 1·14–2·06, p = 0·004]), depression (OR 1·6 [95% CI 1·07–2·31, p = 0·021]), and overall psychological distress (OR 1·9 [95% CI 1·26–2·99, p = 0·005]). Prospectively reporting four or more ACEs is associated with a greater than twofold increase in risk for somatization and overall psychological distress (OR 2·7 [95% CI 1·42–3·53, p = 0·003], and OR 2·2[95% CI 1·58–3·12, p = 0·008], respectively).

3.4. The influence of recent stressors

Reports of recent stressors show a strong and graded influence on anxiety, somatization, depression and overall psychological distress. The higher the number of recent stressors reported the greater the risk for negative mental health outcomes; the odds of experiencing somatization, anxiety and overall psychological distress more than doubling when four or more recent stressors are reported (OR 2·3 [95% CI 1·47–3·47, p = 0·000], OR 2·5 [95% CI 1·50–4·12, p = 0·000], and OR 2·5 [95% CI 1·63–3·96, p = 0·000], respectively). Recent stressors have a slightly weaker influence on depression but still increase the odds (OR 1.8 [95% CI 1·05–3·13, p = 0·034]). When accounting for recent stressors, adjusted odds ratios between retrospective ACEs and mental health outcomes decrease, suggesting that recent stressors independently contribute to poor mental health outcomes, but may well bias retrospective recall itself.

Factorial analysis of variance examining the effects of recent stressors and ACEs on psychological distress (Supplementary Table D) yielded significant models for both prospective ACEs [F(9, 1505) = 8·35, p = 0·000)] and retrospective ACEs [F(9, 1505) = 10·11, p = 0·000)]. For the prospective model, recent stressors (p = 0·000) and prospective ACEs (p = 0·023) were independently and significantly associated with psychological distress, but there was no significant interaction between recent stressors and prospective ACEs (p = 0·501). For the retrospective model, recent stressors (p = 0·000) and retrospective ACEs (p = 0·000) were independently and significantly associated with psychological distress, but again there was no significant interaction between recent stressors and retrospective ACEs (p = 0·976).

Figs. 6 and 7 show the plotted analysis of variance results for the number of recent stressors reported in adulthood compared to the number of prospectively or retrospectively reported ACEs by psychological distress. The number of recent stressors reported in young

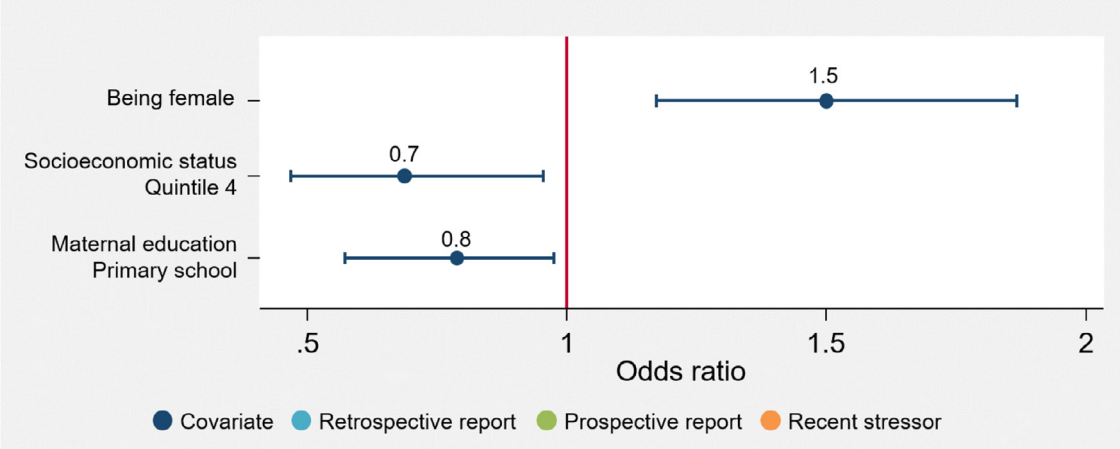

Fig. 3. Adjusted effects of reported ACEs and covariates on social dysfunction
This figure shows the fold-increase in the odds of experiencing levels of social dysfunction indicating psychological distress given reports of retrospective and prospective ACEs and additional covariates, including recent stressors. Odds ratios (ORs) and their respective confidence intervals for the adjusted model are available in Supplementary Table F.

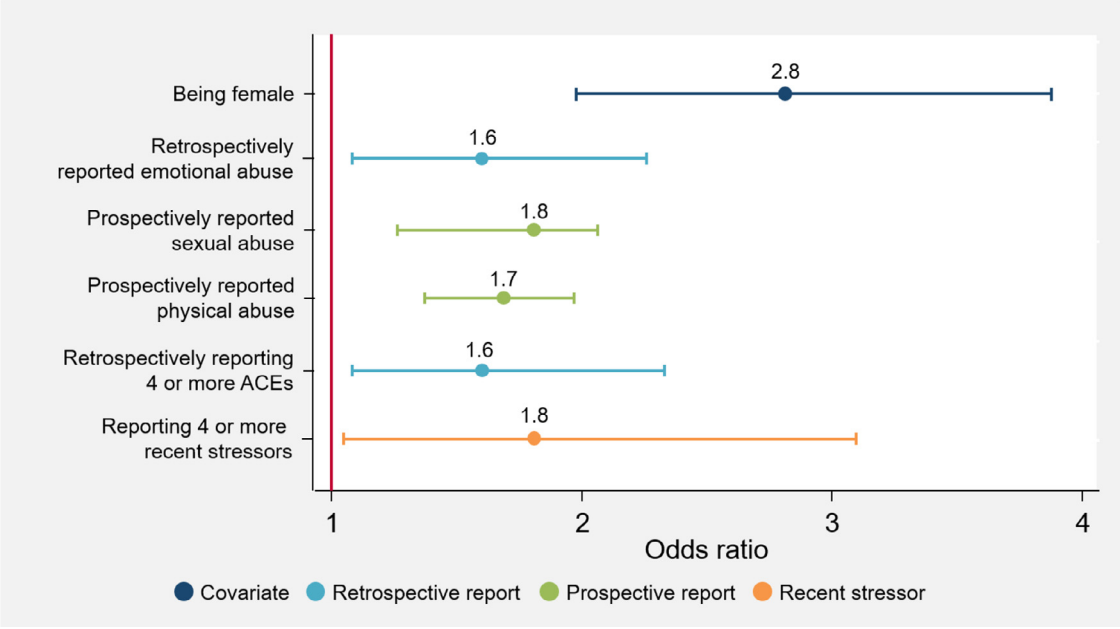

Fig. 4. Adjusted effects of reported ACEs and covariates on depression
This figure shows the fold-increase in the odds of experiencing levels of depression indicating psychological distress given reports of retrospective and prospective ACEs and additional covariates, including recent stressors. Odds ratios (ORs) and their respective confidence intervals for the adjusted model are available in Supplementary Table F.

adulthood appears to have less of an association with the number of ACEs prospectively experienced (Fig. 6) compared to the association between the number of recent stressors and retrospective ACEs (Fig. 7) where a steeper climb is apparent. For both retrospective and prospective ACEs, participants presenting with distress report on average more recent stressors than those not presenting with distress as the number of ACEs increases. The inlaid boxplots in Figs. 6 and 7 show the variability in recent stressors across prospective and retrospective ACEs, with less variance in the number of recent stressors when participants report lower numbers of ACEs compared to when they report *three* or *four or more* ACEs. For prospective ACEs the upper 25% of participants presenting with distress report on average higher numbers of recent stressors than their counterparts in each of the ACE categories. The same is true for retrospective ACEs apart from a smaller group of participants who present with distress, report relatively low ACEs (*two*), and between zero and two recent stressors.

4. Discussion

The number of ACEs reported does not appear to have any association with social dysfunction. Instead, sociodemographic variables such as sex, socio-economic status and maternal education account for the variations in the social dysfunction scale. Given the socio-political climate in South Africa, characterized by a poor education system – where about 60% of youth have either left school before graduation, or do not graduate [33], high youth unemployment rates, and resultant poverty, young adults may find themselves generally unprepared for functioning independently. This, and cultural issues specific to a young adult South African sample, could explain the contrasting findings on the social dysfunction subscale compared to the other subscales.

Extended to the other domains of the GHQ, the findings of this study indicate that both prospective and retrospective reports of

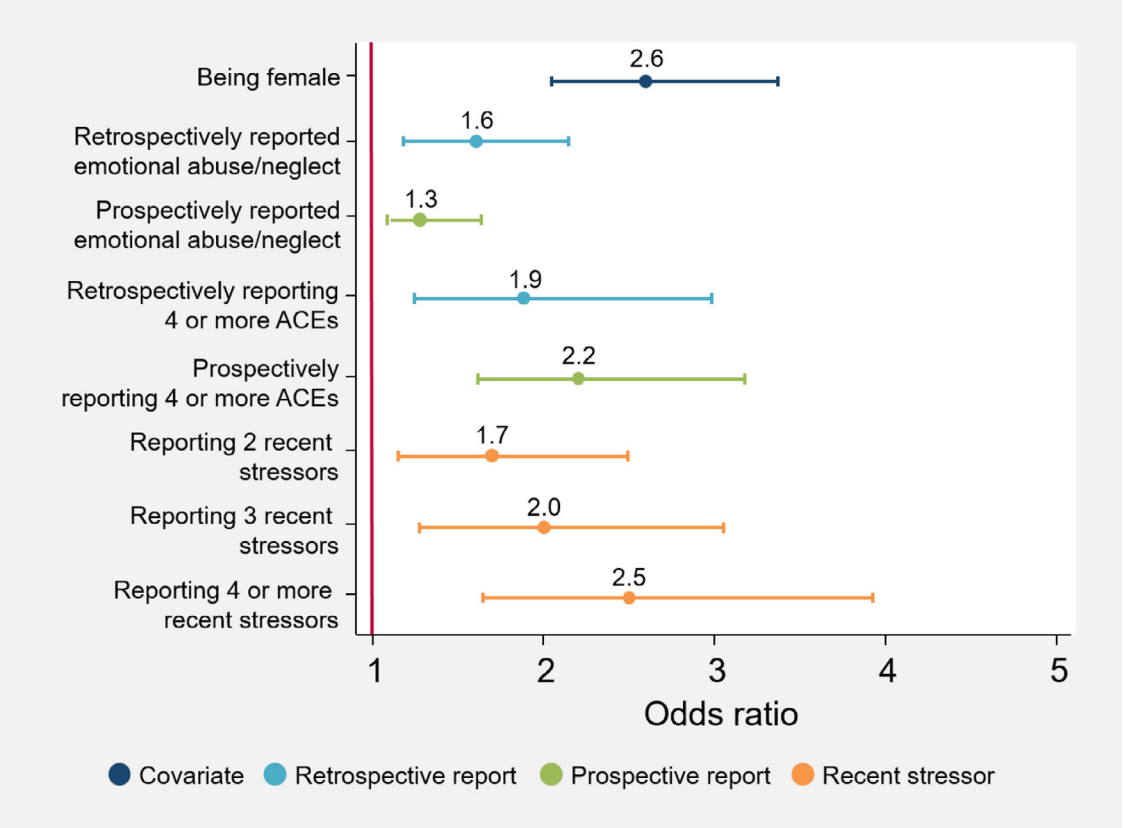

Fig. 5. Adjusted effects of reported ACEs and covariates on the total GHQ score

This figure shows the fold-increase in the odds of experiencing psychological distress as indicated by total GHQ scores given reports of retrospective and prospective ACEs and additional covariates, including recent stressors. Odds ratios (ORs) and their respective confidence intervals for the adjusted model are available in Supplementary Table F.

ACEs can be linked to mental health in young adulthood. Young adults prospectively reporting four or more ACEs are more than twice as likely to experience psychological distress than those reporting less than four ACEs. While lower in prevalence than prospectively reported ACEs, retrospectively reported ACEs have a stronger association with anxiety, depression, somatization and general psychological distress in young adulthood. Similar studies have linked ACEs, individually and in combination, to mental health outcomes in general [26,34] and the GHQ in particular [35]. Heim and colleagues propose that early adverse experiences not only contribute to the manifestation of some types of depression, as evidenced in this study, but likely influence treatment responses [36].

Distal ACEs like chronic household unemployment, household legal trouble and low socio-economic status do not appear to have persistent influence over the mental health of young adults in this sample. Research has shown that relative to a history of either *no* or *high* cumulative lifetime adversity, a history of *some* adversity is associated with better mental health and wellbeing [37]. Counterintuitively, prospective chronic unemployment in the household appears to have a protective effect on somatization and anxiety in this study. The pervasiveness of adversity – in the distal form – throughout a community may in some sense lead to a 'normalization' of poverty and hardship that engenders a resilience in South African youth, mitigating its impact on mental health. In contrast, proximal ACEs such as physical, sexual and emotional abuse have a lasting effect on children, both in memory and in their effect on mental health, with retrospective and prospective physical abuse and emotional abuse/neglect and prospective sexual abuse linked to increased risk for depression, anxiety and general psychological distress.

The decrease in prevalence of retrospectively reported ACEs, compared to those reported prospectively, may be a result of a life view composed over time and filtered through recent stressors. Stressful life events are thought to negatively impact multiple areas of psychosocial functioning in general [38]. This study finds that there is an association between the number of recent stressors reported and the number of prospectively and retrospectively reported ACEs, that these reports of ACEs will be associated with poor mental health; but also that these associations are not straightforward. Young adults who prospectively report four or more ACEs, and those who retrospectively report any number of ACEs, with the strongest effect on four or more, are more likely to report a greater number of recent stressors. This effect of recent stressors has been assessed previously. One study found that stressful live events were associated with higher alcohol consumption among women exposed to childhood maltreatment, but could not find evidence for the role of recent events in the alcohol consumption of women not exposed to maltreatment [39]. Adversity experienced in childhood may sensitize individuals to future negative events, aggravating negative outcomes, which could explain the link between retrospective reporting, recent stressors and poorer later life outcomes. This finding may support a stress-sensitization hypothesis that early adversity leads to psychobiological changes that heighten sensitivity to subsequent stressors, altering strategies for coping with stress [40] and vulnerability to negative outcomes [41-43]. Harkness and colleagues assessed the relationship between childhood abuse and neglect and stressful life events for adolescents with depression and proposed that maltreatment may be an important risk factor that sensitizes individuals to the effects of acute independent life events [44]. Similar results were found in a psychiatric sample of adolescents; the timing and number of negative life events increased the risk of emotional and behavioral disorders by 3–6 times [45]. Honkalampi and colleagues suggest that ACEs may predispose individuals to depression, but current stressful

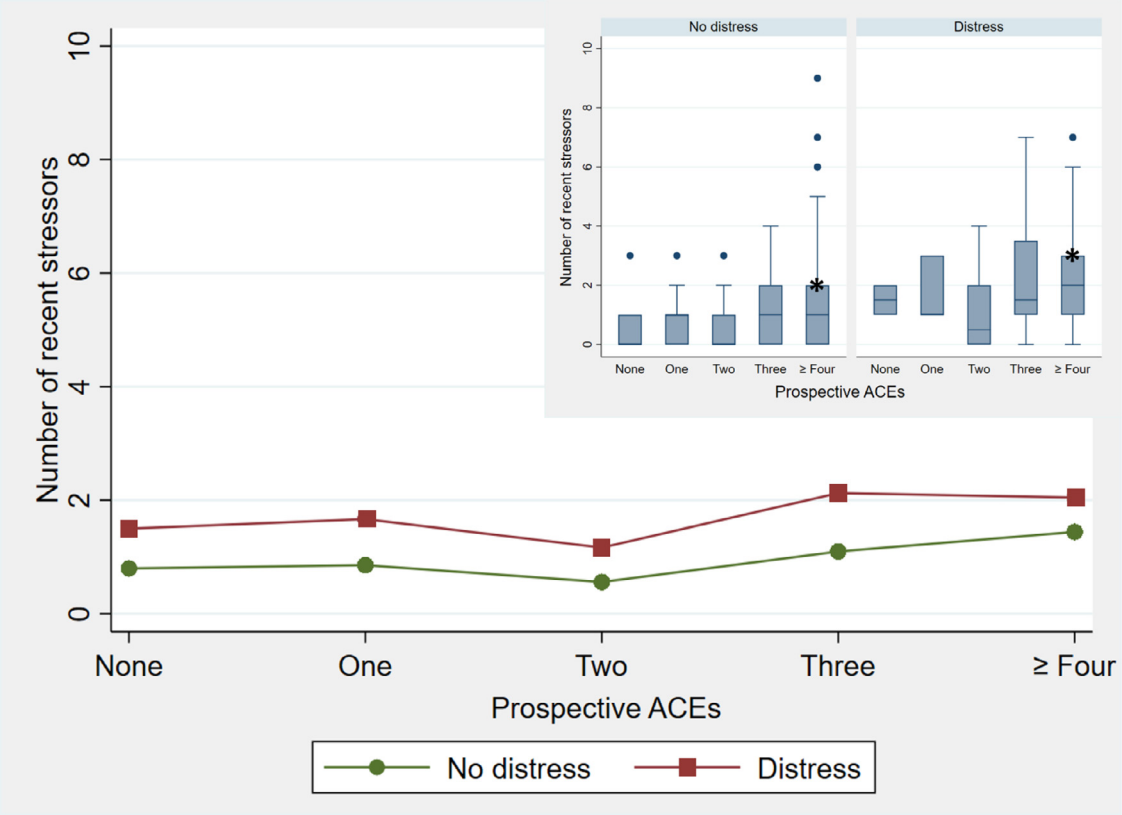

Fig. 6. Comparison of the number of recent stressors by psychological distress for prospectively reported ACEs

This figure shows in the larger graph the average number of recent stressors reported by participants presenting no distress on the GHQ (green, circle symbol) compared to those presenting with distress (maroon, square symbol) for categories of prospectively reported ACEs, with an inlay of the boxplot distribution of the same showing the median number of recent stressors, by distress status, as well as outliers. The boxes represent the interquartile range, with the median number of recent stressors indicated by the center line, and the whiskers represent the lowest and highest observations. No whiskers are visible where the lowest quartile is equal to the lowest observation or the upper quartile is equal to the highest.

events actualize these symptoms [46]. Recent stressors seem to reinforce a stress accumulation model — whereby early life stressors and subsequent stressors have unique and additive contributions; [47,48] supporting the idea that a number of mechanisms may work to link ACEs differentially to outcomes, whether psychological, physiological or behavioral. We propose that recent stressors have a confounding effort on the relationship between reports of ACEs and mental health outcomes; directly impacting mental health and possibly influencing autobiographical memory involved in retrospective recall. Further research should focus on the trajectories and pathways of groups of individuals who report prospective and retrospective ACEs and recent stressors.

While this study's findings show that males and females generally report similar numbers of ACEs prospectively, and males report significantly more ACEs retrospectively, females are up to twice as likely to suffer psychological distress as a result of these experiences. Stress-related disorders such as anxiety and depression are disproportionately prevalent in women. Literature suggests that stress and gonadal hormones may interact to predispose women to depression and anxiety; [49] adding further complexity in the form of sex to the relationship between ACEs, recent stressors and mental health. Mental health assessments that capture externalized emotions and behavior such as conduct disorder and aggression may better explain how adversity in childhood affects the mental health of young men.

Further research is required to tease out the mechanisms by which ACEs affect mental health using both subjective and objective, and prospective and retrospective reports. The continually contentious challenges around retrospective recall are somewhat allayed with emerging evidence of their links to both subjectively and objectively assessed negative outcomes. However, research cautions that psychopathology prior to or at the time of recall may bias memory towards either recalling a greater number of negative events, an exaggeration of some memories or a focus on painful ones [50]. This may denote a circular relationship between mental health and retrospective recall of ACEs or as Hardt and Rutter infer, that mental health is the filtering out of negative memories or their reimagining as benign [50].

The authors acknowledge a number of limitations in the study. The first set relate to the ACEs measure and method of collection. Measurement error in retrospective designs can be caused by a number of factors, including memory lapse over time [51], cognitive functioning at the time of the event in question [52], the non-disclosure – whether voluntary or involuntary – of memories and specific details in the case of sensitive or traumatic experiences [51], and differential recall bias due to the participant's current life status and mood state at the time of reporting on past events [53]. Studies have cautioned on the sole use of retrospective accounts, particularly when assessing experiences prone to subjective judgment, but maintain that their usefulness in research cannot be negated and is enhanced when paired with additional sources, as in the current study [14,50,54]. With regard to the ACEs measure, the original ACEs inventory is limited in the type of adversities included which have been extended in this study and others, but room remains for further refinement of a more comprehensive set of ACEs. Additional limitations of ACE scores are that they do not distinguish between single episode, recurrent or chronic adversities and that the cumulative risk approach to scoring and summing of individual ACEs considers each as equivalent to the next. As a trade-off, the cumulative ACE score

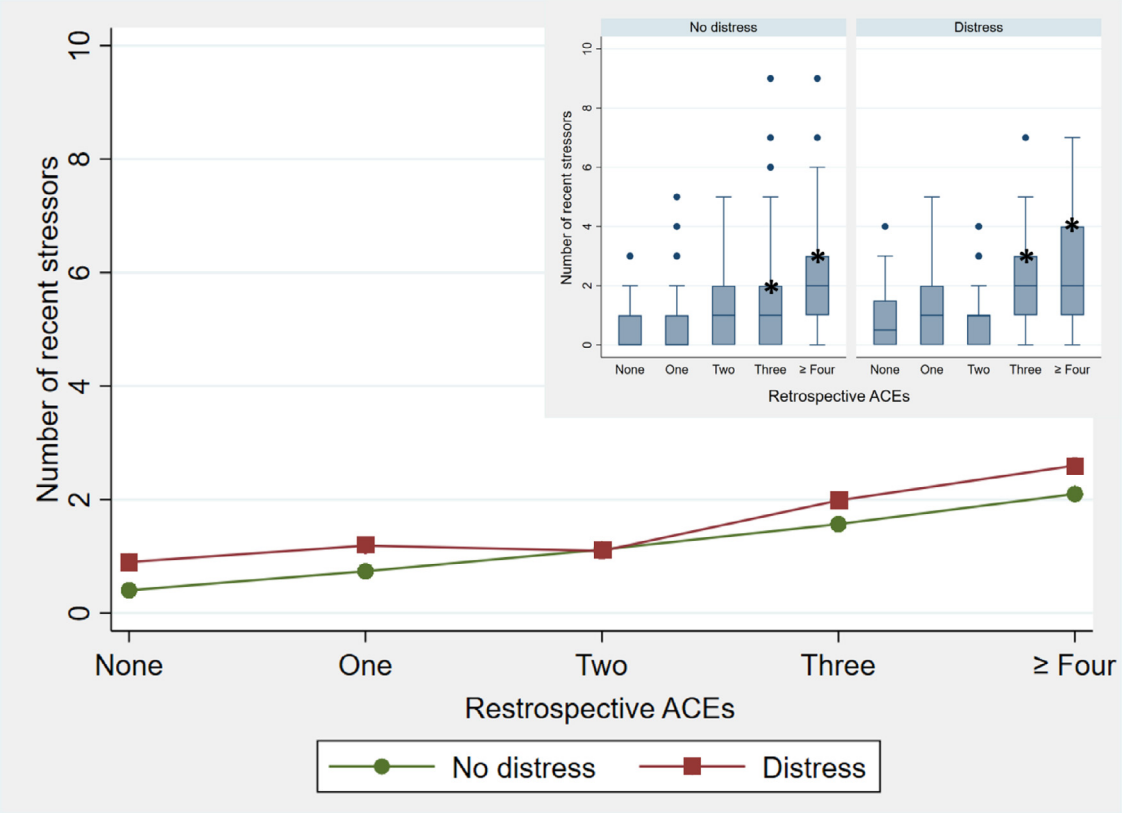

Fig. 7. Comparison of the number of recent stressors by psychological distress for retrospectively reported ACEs

This figure shows in the larger graph the average number of recent stressors reported by participants presenting no distress on the GHQ (green, circle symbol) compared to those presenting with distress (maroon, square symbol) for categories of retrospectively reported ACEs, with an inlay of the boxplot distribution of the same showing the number of recent stressors, by distress status, as well as outliers. The boxes represent the interquartile range, with the median number of recent stressors indicated by the center line, and the whiskers represent the lowest and highest observations. No whiskers are visible where the lowest quartile is equal to the lowest observation or the upper quartile is equal to the highest.

enables more precise and quantifiable examination and a number of studies have demonstrated a strong dose-response relationship between the ACE score and later life health and well-being outcomes [8,55,56].

The second set of limitations to this study relate to the data within Bt20+. At the 22–23-year data collection wave, and similar to all birth cohort studies, Bt20+ had an attrition rate of 50% due to a range of factors, including local migration patterns, which have been explored and described elsewhere [29,57]. Previous analysis on the same 22–23-year data on ACEs found no significant differences by sex and SES, the two covariates used in this study, between the participants surveyed and those not surveyed at the 22–23-year wave [58]. The authors make no claims about the generalizability of the results to the South African population but maintain that the initial cohort size (3273) was large enough at the start to mitigate the effects of attrition on internal validity.

In conclusion, this study finds the number, type and time of recall of ACEs have differential impacts on mental health in early adulthood. Both prospective and retrospective reports of ACEs are linked to psychological distress, with a stronger association between retrospective reports, and recent stressors reinforcing this relationship. Females are twice as likely to report poor mental health outcomes albeit reporting similar or fewer ACEs but the mental health assessment used in the study may not be capturing expressions of psychological distress in young males. The overall findings suggest that retrospective reports of ACEs can effectively screen for psychological distress in early adulthood and that the presence of recent stressors will be an exacerbating factor.

Author contributions

SAN and LMR managed the study, including funding acquisitions, and oversaw implementation. SNN, SAN and LMR conceptualized the paper, curated and validated the data. SNN analysed the data. SNN and LMR wrote the manuscript with contributions from SAN. All authors reviewed the study findings and read and approved the final version before submission.

Declaration of Competing Interest

The authors declare no competing interests.

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Data sharing statement

Interested researchers should contact the Birth to Twenty Plus Executive Committee if they wish to obtain the cohort data. Authors from respective publications can be contacted for access to analytic datasets used in papers.

Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.eclinm.2021.101094.

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Appendix 3: The Long-Term Health and Human Capital Consequences of Adverse Childhood Experiences in the Birth to Thirty Cohort: Single, Cumulative, and Clustered Adversity

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The Long-Term Health and Human Capital Consequences of Adverse Childhood Experiences in the Birth to Thirty Cohort: Single, Cumulative, and Clustered Adversity

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Abstract: Human capital—that is the cumulative abilities, education, social skills, and mental and physical health one possesses—is increasingly recognized as key to the reduction of inequality in societies. Adverse childhood experiences have been linked to a range of human capital indicators, with the majority of research in high-income, western settings. This study aims to examine the link between adverse childhood experiences and adult human capital in a South African birth cohort and to test whether associations differ by measurement of adversity. Secondary analysis of data from the Birth to Thirty study was undertaken. Exposure data on adversity was collected prospectively throughout childhood and retrospectively at age 22. Human capital outcomes were collected at age 28. Adversity was measured as single adverse experiences, cumulative adversity, and clustered adversity. All three measurements of adversity were linked to poor human capital outcomes, with risk for poor human capital increasing with the accumulation of adversity. Adversity was clustered by quantity (low versus high) and type (household dysfunction versus abuse). Adversity in childhood was linked to a broad range of negative outcomes in young adulthood regardless of how it was measured. Nevertheless, issues of measurement are important to understand the risk mechanisms that underlie the association between adversity and poor human capital.

Keywords: adverse childhood experiences; ACEs; human capital; birth cohort; clustered adversity

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1. Introduction

Human capital is collectively the knowledge, skills, and health inputs accumulated across the lifespan that enables individuals to realize their full potential and contribute to the economic productivity of a society. It is manifest through a range of constructs, including educational attainment, physical and mental health, and social outcomes. It is well documented that human capital trajectories vary greatly within communities [1] and that one's early experiences account for a substantial portion of the variation in adult human capital outcomes [2–4]. Another construct linked to economic productivity is adverse

childhood experiences (ACEs), which is related to poorer health and social outcomes—or human capital—across the life course [5–7]. Early adversity in general, including child maltreatment, has long been established as detrimental for health and wellbeing [8,9]. Furthermore, the concept of ACEs—a quantifiable index of exposure to a range of adverse experiences, has in recent years been linked to a range of negative outcomes. The original ACE study found significant associations between ACEs and risk for alcoholism, drug abuse, smoking, risky sexual behavior, obesity, depression, suicide attempt, heart disease, cancer, chronic lung disease, liver disease, and skeletal fractures [10]. Following this seminal study, publications linking ACEs to one or more outcome grew exponentially [11] and systematic reviews and meta-analyses provided valuable overviews. One meta-analysis reviewed 37 studies and described links between greater exposure to ACEs and physical inactivity, overweight, obesity, diabetes, smoking, heavy alcohol use, sexual risk behavior, cancer, heart disease, respiratory disease, and mental ill health [7]. A second meta-analysis assessed 96 studies in which ACEs were examined against health and wellbeing outcomes. The study's findings mirrored those of the previous meta-analysis, linking ACEs to a range of psychosocial, behavioral, and physical health outcomes [6]. Finally, a third meta-analysis on studies from Europe and North America not only connected ACEs to risk factors for ill health, but estimated the associated annual financial costs attributable to ACEs to be $581 billion in Europe and $748 billion in North America [12]. Identifying the specific ACEs or combinations of ACEs that are strongly linked to adult human capital outcomes may help elucidate the mechanisms of these associations and aid in developing targeted interventions to reduce the risk of poor human capital outcomes.

However, the measurement of ACEs has important limitations. Studies typically rely on cumulative risk scores [13] or individual adversities measured through retrospective self-reports [14]. Evidence describes the relationship between ACEs and social and health problems as one that predicts the risk to increase in a strong and graded manner as the number and severity of ACEs increase [15,16]. Hence, a single adversity approach ignores the high probability that adversities co-occur and have an exponential impact. On the other hand, cumulative risk scores assume equal weighting of adversities while a number of studies have shown specific ACEs to be more deleterious than others [17–19]. Although there are currently no guidelines on the ACEs scoring in the available literature, some studies point to the 'four or more' cut-off functioning as a threshold level, with noticeable deviations in a range of outcomes at that mark [7]. As an alternative to both of these approaches, analyses of the patterning of ACEs recognize that the clustering and qualitative differences in combinations of ACEs are important for health and social outcomes and are linked to different consequences [20,21].

Another important limitation in ACEs research is the reliance on retrospective reports [6]. Previous research in longitudinal birth cohorts has demonstrated that prospective and retrospective reports of ACEs show poor agreement [22,23], similar to findings in this cohort [24], and are differentially linked to outcomes [17,23]. Meta-analysis findings conclude that prospective and retrospective measures of ACEs largely identify two different sets of individuals, cautioning that the measures should not be used interchangeably to study pathways of risk and outcomes. It is therefore important to compare findings based on prospective and retrospective measures in the same individuals.

Conceptually, frameworks such as the ACEs Pyramid—emanating from the ACEs study—attempt to explain the ways in which early adversity disrupts biological and psychological processes through interactions between genes and the environment [25]. The bio-developmental framework posits that early adversity precedes physiological maladaptations and disruptions due to either cumulative exposure or biological embedding during sensitive periods, leading to a range of poor health and wellbeing outcomes [26]. The ACEs Pyramid follows this logic but recognizes that exposure to ACEs is somewhat predetermined by social conditions and historical trauma in societies. ACEs then go on to disrupt neurodevelopment, giving rise to socio-emotional and cognitive impairments linked to

the adoption of health risk behaviors that increase vulnerability to disease, disability, and social problems [10].

The objectives of this study are therefore to (a) examine the associations between ACEs and adult human capital, and (b) explore how the measurement of ACEs may vary in relation to these human capital outcomes. Prior research, including studies using this cohort, have highlighted sex differences in the prevalence of ACEs and their associations with outcomes [17,24,27–30]. The patterning of ACEs and their links to human capital outcomes will be disaggregated by sex throughout this analysis. To our knowledge, no study to date has investigated the relationship between ACEs and adult human capital outcomes, using these unique measurement methods, in low–middle income countries (LMICs).

2. Materials and Methods

2.1. Study Design and Participants

The Birth to Thirty study (Bt30, previously known as Birth to Twenty Plus) is a South African birth cohort of all singleton children born to mothers who were residents of Soweto, Johannesburg in a 7-week period of enrolment in 1990 [31]. The study is the largest and longest running birth cohort on the African continent, with an initial recruitment of 3273 participants, including their primary caregivers and subsequently a third generation born to the original cohort. The study has routinely followed participants through 23 data collection points over its 30-year lifespan, assessing growth, health, education, and well-being domains. At each of the data collection waves, well-trained field staff conducted face-to-face interviews with each participant for all interviewer-administered questionnaires and were available to assist with all self-administered questionnaires. A set of core questionnaires were routinely administered at each wave, assessing socio-demographics, household information, community and school environment, health and nutrition, risk behaviors, and more. The exposures and outcomes used in this study were pulled from selected sections in these questionnaires. Detailed descriptions of the cohort methods and sample have been published elsewhere [31–34]. For this study, data on 1436 participants included in the last data collection wave at age 28 were used. Ethics clearance was obtained from the Witwatersrand University Committee for Research on Human Subjects and written consent was obtained from all participants.

2.2. Exposures

ACEs in this study are defined as physical abuse, sexual abuse, emotional abuse or neglect, household dysfunction in the form of experience of divorce or parental separation, child separation, exposure to intimate partner violence (IPV), experience of living with a chronically ill or disabled individual or an individual with substance abuse problems, parental death, household legal trouble, and chronic household unemployment. ACEs were taken from a 'life events' section in the routine Bt30 questionnaire, which probed for recent major life events or changes (Supplementary Table S1). Retrospective reports of individual ACEs were created from a single report in the 22–23-year data collection wave. Prospective reports of individual ACEs were composed across the first 18 years of available data from caregiver reports (children aged 0–7 years old) and self-reported by the Bt30 participant thereafter.

2.3. Outcomes

Human capital outcomes were measured at age 28 and include both health and social measures conceptualized in a previous study [2].

2.3.1. Education and Employment

Education refers to incomplete secondary schooling. Participants reported their highest school grade attained, dichotomized into complete (coded 0) or incomplete (1) secondary education. For the employment outcome, participations reported whether they were formally employed (i.e., had a work contract), (coded '0') vs. not formally employed ('1').

Both education and employment were single questions under their respective sub-sections in the routine Bt30 questionnaire at age 28.

2.3.2. Welfare Receipt

Welfare receipt refers to a government cash transfer available to primary caregivers of children who qualify through an income means test. Welfare receipt in the form of a Child Support Grant (yes, coded '1', vs. no, '0') was recorded from administrative data supplied by the South African Social Security Agency. A single variable indicating whether or not the individual is receiving the grant was linked to the Bt30 data. Participants consented to the linking of this data through identity numbers.

2.3.3. Mental Health

Mental health was conceptualized as psychological distress and assessed using the World Health Organization's Self Reporting Questionnaire. Items include 20 questions assessing symptoms experienced during the past month, such as "Do you feel nervous, tense or worried?" and "Do you sleep badly?", coded in a binary manner and summed to obtain a total psychological distress score (alpha = 0.93). Participants in the top 20% of symptoms score were considered as having high psychological distress.

2.3.4. Social Isolation

Social isolation was assessed using 8 items based on the Inventory of Socially Supportive Behaviors, such as "How often you had someone who would listen to you when you needed to talk", "Had someone you trust to talk with about your problems". Items were answered on a 5-point scale from never to always, and then summed. Scores were dichotomized to identify participants who reported high levels of social isolation (scoring at the bottom decile of the distribution was coded '1', versus those reporting lower levels, coded '0').

2.3.5. Substance Abuse and Criminality

Substance abuse was derived from either reporting alcohol use more than 2–3 times a week and/or current use of non-medical drugs (including marijuana), scored as yes ('1') or no ('0'). Criminality was assessed by asking participants whether, in the last year, they had been arrested, detained, jailed, or committed a crime without being caught, for example, stolen a car/motorbike, stolen in a shop or from a person, sold drugs or stolen goods, set property on fire or damaged/destroyed property, assaulted someone, or forced someone to have sex. A positive answer to any of the questions was coded '1' versus '0'. These questions were taken from a section on 'delinquency' in the Bt30 routine questionnaire.

2.3.6. HIV Infection

HIV status was assessed with a single question asking, "Have you ever tested positive for HIV?", coded '1' if yes and '0' if no.

2.4. Covariates

Covariates were included in this study based on their significance in the literature to multiple health and wellbeing outcomes [35,36], including in prior work on this cohort [2,17]. The covariates include sex; socio-economic status at participant birth, age 12, and age 22, measured as wealth quintiles derived from a list of assets (e.g., television, fridge, car, phone); maternal age at birth sorted into 4 age categories based on the distribution of maternal age (15–18, 19–24, 25–34, 35–46), and continuous measures of maternal and paternal years of schooling.

2.5. Statistical Analysis

Measuring ACEs

Single ACEs were included in the analyses as individual binary variables. Each ACE was coded '0' for a negative response and '1' for a positive response.

To measure the effects of cumulative adversity, the individual binary ACEs were transformed into a categorical score with 5 levels for each participant, as follows: 0 = 'no reported ACEs', 1 = 'one reported ACE', 2 = 'two reported ACEs', 3 = 'three reported ACEs' and 4+ = 'four or more reported ACEs', following convention in the literature and allowing for comparability with other studies. The Bt30 sample has limited variability in its socio-economic status, similar low variability in the distribution of ACEs, and high prevalence of ACEs, given that the site of the study (i.e., Soweto, Johannesburg) is a previously socio-economically disadvantaged and low-income area. Most studies assessing either prospective or retrospective ACEs are based in high-income countries, often with populations with more heterogeneity in the distribution of ACEs [22]. To maximize within-cell counts and meaningfully analyze the data, cumulative ACEs were also categorized in a binary fashion as '0' = 'less than six' and '1' = 'six or more' reported ACEs. The 'six or more ACEs' cut-off was preferred over the conventional cut-off of '4 or more ACEs' as this represents the mean ACE score for the Bt30 sample and takes into account the higher prevalence of ACEs in the sample.

Clusters of ACEs were derived using latent class analysis (LCA), a mixture model technique that identifies groups of individuals (i.e., latent classes) on the bases of similarities in their pattern of co-occurrence of ACEs exposure. LCA was separately applied to the prospective and the retrospective reports. Several models were estimated with 2 to 6 latent classes and compared using the Bayesian Information Criteria (BIC, used as primary index), Akaike's Information Criteria (AIC), and sample size-adjusted BIC (SSABIC). Lower values of the BIC, AIC, and SSABIC indicate a better fitting model. Entropy was also used to assess the distinction between classes, where values closer to 1 indicate good distinction (Supplementary Table S2). Once the best model was identified, participants were assigned to their most likely class, creating a categorical cluster variable. LCA was performed with Mplus version 8, with missing data on ACEs variables handled using Full Information Maximum Likelihood.

Associations between the 3 methods of measuring ACEs—single, cumulative, and clustered—and human capital outcomes—were examined using logistic regression. Two sets of models were fitted for each ACE measurement for both retrospective and prospective reports of ACEs: (i) a crude, unadjusted model (Supplementary Tables S3 and S4), followed by (ii) models adjusted for all covariates (Supplementary Tables S5 and S6). Sex was included as a covariate in all models but separate analysis by sex, excluding the variable at the covariate level, was conducted and is available in Supplementary Tables S7 and S8. To handle missing data on the covariates, we used multiple imputation by chained equations, so that models were estimated across 10 datasets and then pooled. All data management, multiple imputation, and regression analyses were conducted in Stata version 15.1. Data missingness for each of the ACEs, covariates, and outcomes is detailed in Table 1.

Table 1. Description of the study sample (n = 1436).

Variable	Male	Female	Total	Missing
Exposures				
Single Prospective ACEs				
Physical abuse	400 (58.57)	381 (50.73)	781 (54.65)	2 (0.14)
Sexual abuse	267 (39.09)	278 (37.17)	545 (38.13)	5 (0.35)
Emotional abuse	245 (35.98)	265 (35.43)	510 (35.71)	7 (0.49)
Child separation	92 (14.00)	120 (16.28)	212 (15.14)	42 (2.92)
Parental divorce	332 (49.63)	392 (52.55)	724 (51.09)	21 (1.46)
Parental death	160 (23.74)	152 (20.27)	312 (22.01)	12 (0.84)
Household death	416 (64.63)	463 (61.49)	879 (63.06)	8 (0.56)

Table 1. *Cont.*

Variable	Male	Female	Total	Missing
Household substance abuse	305 (46.42)	355 (48.30)	660 (47.36)	44 (3.06)
Household illness/disability	413 (62.86)	460 (62.42)	873 (62.64)	42 (2.92)
Household legal trouble	292 (43.20)	228 (30.32)	520 (36.76)	8 (0.56)
Chronic unemployment	567 (86.30)	634 (86.02)	1201 (86.16)	42 (2.92)
Exposure to IPV	372 (54.55)	285 (37.95)	657 (46.25)	3 (0.21)
Exposure to violence	530 (77.71)	474 (63.03)	1004 (70.37)	2 (0.14)
Prospective ACE category				0 (0.0)
0 ACEs	3 (0.44)	5 (0.66)	8 (0.55)	
1 ACE	12 (1.76)	14 (1.86)	26 (1.81)	
2 ACEs	13 (1.90)	30 (3.98)	43 (2.94)	
3 ACEs	49 (7.17)	62 (8.23)	111 (7.70)	
4+ ACEs	606 (88.73)	642 (85.26)	1248 (86.99)	
Prospective Binary ACE score				0 (0.0)
Less than 6 ACEs	348 (50.95)	442 (58.70)	790 (55.01)	
6 or more ACEs	335 (49.05)	311 (42.30)	646 (44.99)	
Prospective LCA derived ACEs				0 (0.0)
Class 1: Low adversity	43 (6.30)	70 (9.30)	113 (7.87)	
Class 2: Moderate adversity-dysfunction	223 (32.65)	350 (46.48)	573 (39.90)	
Class 3: Moderate adversity-abuse	127 (18.59)	106 (14.08)	233 (16.23)	
Class 4: High adversity	290 (42.46)	227 (30.15)	517 (36.00)	
Single Retrospective ACEs				
Physical abuse	58 (8.90)	41 (5.75)	99 (7.33)	71 (4.94)
Sexual abuse	16 (2.47)	36 (5.05)	52 (3.76)	74 (5.15)
Emotional abuse	251 (37.19)	241 (32.44)	492 (34.82)	18 (1.25)
Parental divorce	251 (43.35)	276 (44.44)	527 (43.90)	236 (16.43)
Parental death	184 (27.34)	167 (22.57)	351 (24.96)	23 (1.60)
Household death	191 (33.39)	199 (32.20)	390 (32.80)	246 (17.13)
Household substance abuse	205 (30.37)	178 (23.96)	383 (27.17)	18 (1.25)
Household illness/disability	240 (35.50)	277 (37.48)	517 (36.49)	21 (1.46)
Household legal trouble	172 (25.48)	144 (19.38)	316 (22.43)	18 (1.25)
Chronic unemployment	306 (45.33)	296 (39.84)	602 (42.59)	18 (1.25)
Exposure to IPV	81 (12.05)	97 (13.18)	178 (12.62)	28 (1.95)
Exposure to violence	222 (33.04)	160 (21.83)	382 (27.44)	31 (2.16)
Retrospective ACE category				
0 ACEs	58 (8.49)	76 (10.09)	134 (9.29)	
1 ACE	117 (17.13)	135 (17.93)	252 (17.53)	
2 ACEs	98 (14.35)	168 (22.31)	266 (18.33)	
3 ACEs	126 (18.45)	127 (16.87)	253 (17.66)	
4+ ACEs	284 (41.58)	247 (32.80)	531 (37.19)	
Retrospective Binary ACE score				0 (0.0)
Less than 6 ACEs	582 (85.21)	677 (89.91)	1259 (87.67)	
6 or more ACEs	101 (14.79)	76 (10.09)	177 (12.33)	
Retrospective LCA derived ACES				0 (0.0)
Class 1: Low adversity	268 (39.24)	332 (44.09)	600 (41.78)	
Class 2: Moderate adversity-dysfunction	184 (26.94)	203 (16.96	387 (26.95)	
Class 3: Moderate adversity-abuse	109 (15.96)	125 (16.60)	234 (16.30)	
Class 4: High adversity	122 (17.86)	93 (12.35)	215 (14.97)	
Outcomes				
Psychological distress	58 (10.86)	143 (23.68)	201 (17.27)	298 (20.75)
Social isolation	73 (13.67)	45 (7.45)	118 (10.56)	298 (20.75)
Incomplete secondary education	207 (39.06)	152 (25.33)	359 (32.20)	306 (21.31)

Table 1. *Cont.*

Variable	Male	Female	Total	Missing
Unemployed	242 (45.32)	254 (42.12)	496 (43.72)	299 (20.82)
Welfare receipt [1]	5 (1.28)	246 (51.36)	251 (28.82)	565 (39.35)
Criminality	150 (28.04)	32 (5.30)	182 (16.67)	297 (20.68)
Substance use	210 (41.02)	73 (12.74)	283 (26.88)	351 (24.44)
HIV infection	52 (11.13)	96 (16.78)	148 (13.96)	397 (27.65)
Covariates				
Sex	683 (47.56)	753 (52.44)	1436 (100.00)	0 (0.0)
Socio-economic status at birth				115 (8.01)
Quintile 1	101 (16.19)	103 (14.78)	204 (15.49)	
Quintile 2	112 (17.95)	126 (18.08)	238 (18.02)	
Quintile 3	214 (34.29)	240 (34.43)	454 (34.36)	
Quintile 4	135 (21.63)	139 (19.94)	274 (20.79)	
Quintile 5	62 (9.94)	89 (12.77)	151 (11.36)	
Socio-economic status at 12 years				380 (26.46)
Quintile 1	114 (23.12)	123 (21.85)	237 (22.49)	
Quintile 2	164 (33.27)	169 (30.02)	333 (31.65)	
Quintile 3	72 (14.60)	88 (15.63)	160 (15.12)	
Quintile 4	54 (10.95)	71 (12.61)	125 (11.78)	
Quintile 5	89 (18.05)	112 (19.89)	201 (18.97)	
Socio-economic status at 22 years				39 (2.72)
Quintile 1	209 (31.48)	230 (31.38)	439 (31.43)	
Quintile 2	106 (15.96)	116 (15.83)	222 (15.90)	
Quintile 3	154 (23.19)	139 (18.96)	293 (21.08)	
Quintile 4	109 (16.42)	139 (18.96)	248 (17.69)	
Quintile 5	86 (12.95)	109 (14.87)	195 (13.91)	
Maternal age at birth of child				2 (0.14)
15–18 years	72 (10.54)	89 (11.85)	161 (11.20)	
19–24 years	233 (34.11)	254 (33.82)	487 (33.97)	
25–34 years	305 (44.66)	331 (44.07)	636 (44.37)	
35–46 years	73 (10.69)	77 (10.25)	150 (10.47)	
Maternal education, mean (SD)	9.57 (2.63)	9.71 (2.60)	9.64 (2.62)	106 (7.38)
Paternal education, mean (SD)	10.49 (2.43)	10.62 (2.47)	10.56 (2.43)	426 (29.67)

[1] Welfare receipt calculated for the sub-sample who have children (n = 871).

3. Results

3.1. Characteristics of the Sample

Among the 1436 participants in the study, 47.5% were male and 52.4% were female (Table 1). Similar proportions of participants were born to young mothers (11.2% to mothers aged 15–18 at birth and 10.4% to mothers aged 35–44+ at birth), with the majority (78.3%) born to mothers aged between 19–34. Fathers had on average 1 year of additional schooling (mean = 10.5) than mothers (mean = 9.5). At birth, 15.4% of participants were in the lowest wealth quintile compared to 11.4% in the highest, at 12-years-old, 22.4% were in the lowest quintile and 19.0% in the highest, and at age 22, 31.4% fell into the lowest quintile and 13.9% in the highest, leaving a shrinking middle across quintile 2–4 from birth to age 22 of 73.1%, 58.5%, and 54.6%, respectively.

3.2. Prevalence of Human Capital Outcomes

The most prevalent adverse outcomes were unemployment (43.7%), incomplete secondary education (32.3%), substance use (26.9%), and welfare receipt (28.2%). Just over half of the females with children (51.4%) receive welfare compared to 1.3% of males caring for children. While both parents are eligible to receive welfare in the form of the Child Support Grant in South Africa, the greatest number of recipients (over 95% nationally and 98% in this sample), are women [37]. Females reported higher rates of psychological distress (23.7% compared to 10.9%), and HIV infection (16.8% compared to 11.1%) than males. Males reported higher rates of social isolation (13.7% compared to 7.5%), incomplete

secondary education (39.1% compared to 25.3%), criminality (28.0% compared to 5.3%), and substance use (41.0% compared to 12.7%) compared to females.

3.3. Prevalence of ACEs

3.3.1. Single ACEs

The most commonly reported prospective ACEs were chronic unemployment (86.2%), exposure to violence (70.4%), household death (63.1%), and household illness or disability (62.6%). Prospectively, 54.7% of participants reported physical abuse, 38.1% reported sexual abuse, and 35.7% reported emotional abuse. Reported exposure to all single ACEs, with the exception of parental death, decreased in retrospective reports. The most common retrospective ACEs were parental divorce (43.9%), chronic unemployment (42.6%), and household illness or disability (36.5%). Retrospectively, physical abuse was reported at a rate of 7.3%, sexual abuse at 3.8%, and emotional abuse or neglect at 34.8%.

3.3.2. Cumulative ACEs

Similar patterns are seen in the prevalence of cumulative ACEs. While 87.0% of participants report four or more ACEs prospectively, 37.2% report four or more ACEs retrospectively. The proportion of participants reporting no ACEs remains low both prospectively (0.6%) and retrospectively (9.3%). Using the binary cut-off, 55.0% of participants report less than six ACEs prospectively, and 87.7% report less than six ACEs retrospectively.

3.3.3. Clustered ACEs

The best fitting LCA models identified four classes for both the prospective and retrospective ACEs: low adversity (7.9% prospective, 41.8% retrospective); moderate adversity-dysfunction (39.9% prospective, 27.0% retrospective); moderate adversity-abuse (16.2% prospective, 16.3% retrospective); and high-adversity (36.0% prospective, 15.0% retrospective).

Figure 1 shows the predicted probability of each adversity for each of the prospective and retrospective classes that led to the characterization of the classes. For prospective ACEs, *low adversity* was the smallest class, with the highest probabilities being a 28% chance of living in a household in which a member has died and 23% chance of living in a household where a member has a serious chronic illness or disability. Inclusion in the *moderate adversity-dysfunction* class was driven by ACEs related to household dysfunction, namely high chances of chronic unemployment (88%), parent divorce (47%), household death (63%), and household substance abuse (43%), among others. Participants in *moderate adversity-abuse* had a 66% chance of reporting physical abuse, 46% chance of reporting emotional abuse, as well as high levels of chronic unemployment (69% chance), exposure to IPV (83%), and community violence (94%). In the *high adversity* class, the probability of experiencing any one of the ACEs was greater than 40% for 11 of the 13 ACEs.

For retrospective clusters of ACEs, the *low adversity* group was characterized by highest probabilities for parental divorce and household death (31% each). Participants in the *moderate adversity-dysfunction* class had a 26% chance of reporting emotional abuse compared to participants in *moderate adversity-abuse* with a 66% chance of reporting emotional abuse. While those participants in *moderate adversity-abuse* were very unlikely to report chronic unemployment and household legal trouble compared to participants in *moderate adversity-dysfunction* who were almost certainly experiencing those two ACEs. The *high adversity* class had a more than a 40% chance of reporting seven of the 12 ACEs, with an 81% chance of emotional abuse, 73% chance of household illness/disability, 64% chance of household substance abuse, and 60% chance of parent divorce, and were more likely to report chronic unemployment (100%) and household legal trouble (100%).

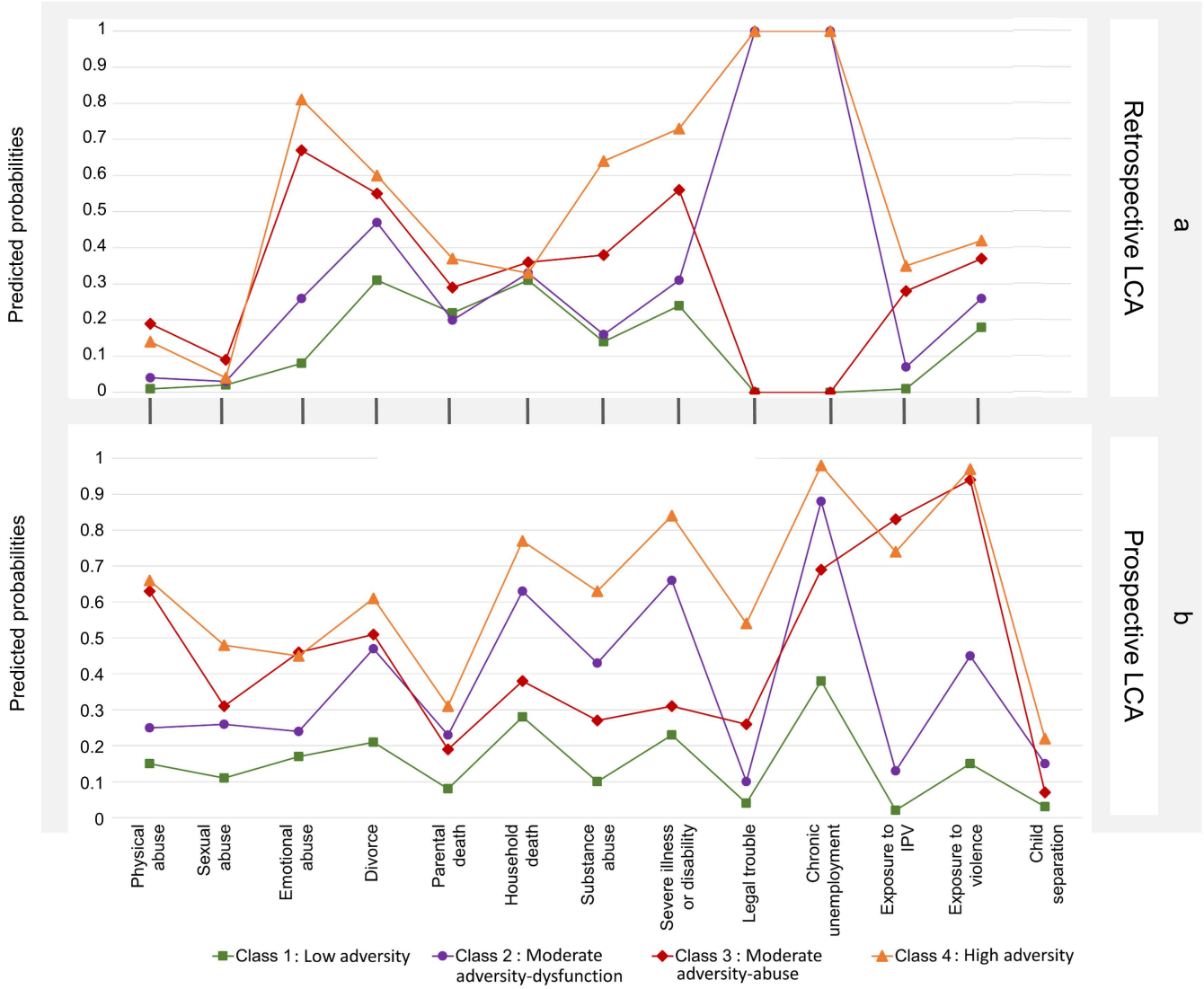

Figure 1. Predicted probabilities for latent class analyses of: (**a**) retrospective ACEs; (**b**) prospective ACEs.

3.4. Associations between ACEs and Human Capital Outcomes

Figure 2 illustrates the significant findings from adjusted logistic regressions displayed for the associations between both prospective and retrospective single ACEs and human capital outcomes for the total sample, which are disaggregated by sex. Figure 3 shows the significant adjusted associations between prospective and retrospective cumulative and clustered ACEs and human capital outcomes, again for the total sample and disaggregated by sex.

3.4.1. Cumulative ACEs and Human Capital Outcomes

The risk for poorer outcomes increased along with the number of ACEs whether reported prospectively or retrospectively. Reporting more than six ACEs prospectively was significantly associated with greater odds of psychological distress (OR 1.63, CI 1.19–2.23), incomplete schooling (OR 1.51, CI 1.15–1.99), unemployment (OR 1.28, CI 1.10–1.64), and criminality (OR 1.80, CI 1.28–2.54) compared to reporting less than six ACEs in the full sample—all of which were only significant for males when disaggregated by sex (OR 1.97, CI 1.11–3.48; OR 1.74 CI 1.20–2.53; OR 1.47, CI 1.04–2.09; OR 1.84, CI 1.22–2.76, respectively). Reporting more than six ACEs retrospectively was associated with increased likelihood of psychological distress (OR 1.72, CI 1.13–1.32) and criminality (OR 1.69, CI 1.09–2.63)

compared to less than six ACEs. Females retrospectively reporting three ACEs and four or more ACEs were 3.5 (CI 1.13–10.38) and 5.4 (CI 2.04–14.51) times more likely to report psychological distress, respectively. Females were 2.8 times (CI 1.18–6.5) more likely to engage in criminality if they experience more than six ACEs and males are more than three times more likely to engage in criminality when they report more than one ACE (OR 3.10, CI 1.05–9.14 for two ACEs; OR 3.97, CI 1.41–11.21 for three ACEs; and OR 3.64, CI 1.27–10.47 for more than four ACEs).

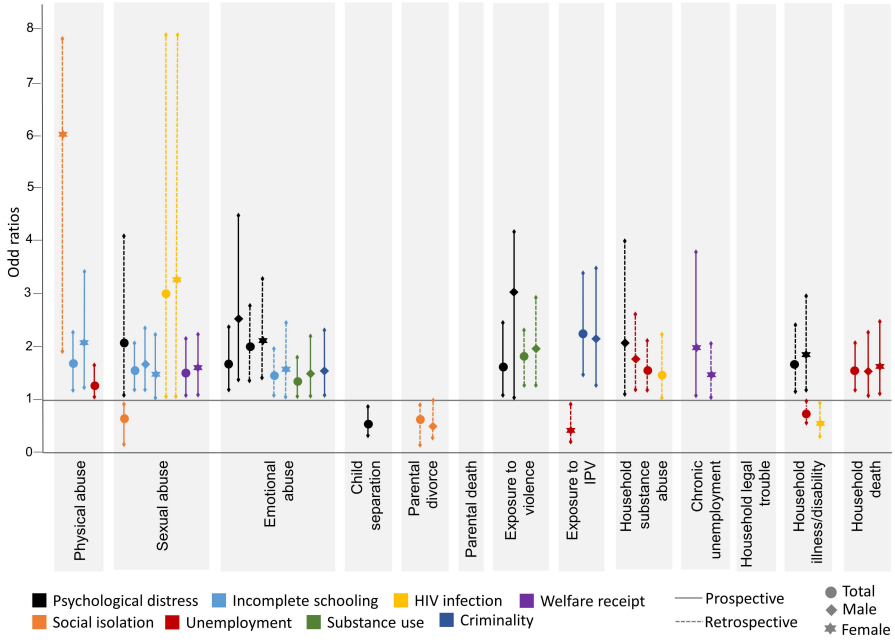

Figure 2. Significant adjusted associations (odds ratios) between single ACEs and human capital outcomes, for the total sample and disaggregated by sex.

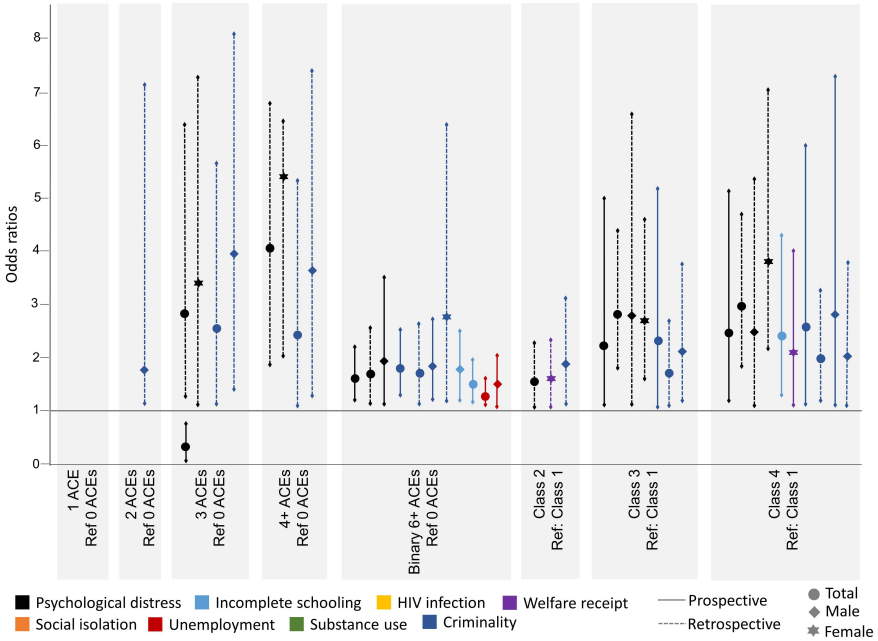

Figure 3. Significant adjusted associations (odds ratios) between cumulative and clustered ACEs and human capital outcomes, for the total sample and disaggregated by sex.

3.4.2. Clustered ACEs and Human Capital Outcomes

Prospectively, compared to the low adversity cluster, the odds of experiencing psychological distress in the moderate adversity-dysfunction cluster are 2.8 (1.18–6.64) for males and 2.71 (1.58–4.63) for females. Individuals in the moderate adversity-abuse cluster are 2.23 times (1.10–5.04) more likely to experience psychological distress and 2.29 times (1.01–5.22) more likely to engage in criminality. Females who fall in the moderate adversity-abuse cluster have a greater likelihood of welfare receipt (OR 1.60, CI 1.06–2.41). The high adversity cluster has greater odds of experiencing psychological distress (OR 2.47, CI 1.19–5.09), incomplete schooling (OR 2.39, CI 1.33–4.32), and criminality (OR 2.60, CI 1.12–6.02).

Retrospectively, when comparing all other clusters to the low adversity group, there is a greater likelihood of psychological distress. The association is strongest in the high adversity cluster (OR 2.97, CI 1.86–4.74), followed by the moderate adversity-abuse group (OR 2.82, CI 1.8–4.41), and lastly the moderate adversity-dysfunction cluster (OR 1.52, CI 1.01–2.29). The moderate adversity-abuse group is also associated with criminality (OR 1.69, CI 1.04–2.73). Males in the high adversity cluster have increased odds for criminality (OR 2.84, CI 1.10–7.34) and females in the same group are more likely to be receiving welfare assistance (OR 2.11, CI 1.10–4.05).

4. Discussion

4.1. Adverse Childhood Experiences and Human Capital

This study aimed to examine the relationship between ACEs and adult human capital outcomes using unique and under-utilized measurement methods of ACEs in comparison to these human capital outcomes. To our knowledge, no other study has drawn on this methodological approach in studying ACEs and none were conducted in the LMIC context of sub-Saharan Africa. This study found that ACEs can be linked to poor human capital outcomes in young adulthood in an urban South African sample. There are a number of individual adversities that are independently associated with human capital outcomes, particularly the abuse-level variables. For example, incomplete schooling is associated with physical, sexual, and emotional abuse; social isolation is associated with physical abuse; and welfare receipt and HIV infection are associated with sexual abuse. The persistent and independent impact that these abuse-level experiences have on health and wellbeing is supported in previous analysis [17]. Individual household dysfunction adversities also play a role in poor human capital outcomes. Household substance abuse was linked to psychological distress and unemployment; exposure to violence was linked to psychological distress and substance use; and household death was linked to unemployment. The cumulative effects of adversity in childhood were also evident. Exposure to greater levels of ACEs, irrespective of their type, was linked to poorer outcomes. Similarly, the clustering of ACEs could be linked to negative human capital outcomes across low-high and dysfunction-abuse planes. There were stronger associations between negative outcomes and ACEs when the *high adversity* group was compared to the *low adversity* group, and similarly when the group likely to experience more abuse was compared to the group likely to experience more household dysfunction.

Globally, and particularly in LMICs such as South Africa, psychological distress contributes substantially to the burden of disease [38]. The prevalence of psychological distress—characterized here by depression, anxiety, and somatic symptoms—in this sample (17.3%) is lower than reported in a nationally representative South African survey (23.9%) [39], although the current study focused on participants expressing the highest levels of psychological distress. Experiences of sexual and emotional abuse, as well as exposure to violence, and substance abuse and severe illness/disability in the household as a child were risk factors for presenting with high psychological distress in adulthood. Individuals with more than three ACEs and in any cluster other than the *low adversity* group were significantly more likely to experience psychological distress. A growing body of research, including in this cohort [17], have linked ACEs to mental illness in various forms:

internalizing and externalizing problems [40], depressive and anxiety disorders [41,42], and personality disorders [43,44]. Some of the possible mechanisms from early adversity to mental ill health include the disruption of adaptive emotion regulation processes, alterations in the structure and function of key areas of the brain, and the development of maladaptive coping strategies [45].

Social isolation, or the objective lack of interaction with others [46], was significantly associated with reported physical abuse in childhood in this study. The implications of prolonged social isolation on mental and physical health in younger populations is still emerging, but evidence of resultant cognitive decline in middle-aged populations [47] and mortality in mixed-aged populations [48,49] is available. As more and more research is conducted, driven by COVID-19-induced social isolation, the persistent and serious consequences of social isolation for health and wellbeing are being recognized [50].

The South African schooling system is divided into four phases, with mandatory attendance in the first three quarters and an optional 4th phase that results in graduation out of the school system [51]. Despite high rates of enrollment in both primary and secondary schooling [52], the rates of incompletion for the latter are alarmingly high, with between 50–60% of learners not completing their secondary schooling [53]. Rates of secondary school incompletion in the current sample are much lower (32.2%) than the national average (~50.0%), but follow the same trend of females more likely to complete than males [54]. The capacity to progress out of school into tertiary education and/or employment is crucial for maximized human capital. Reports of physical abuse, sexual abuse, and emotional abuse in childhood as well as experiencing six or more ACEs cumulatively and being placed in the *high adversity* cluster are significant predictors for incomplete schooling in this study. Similar findings are seen in another birth cohort; retrospective physical and sexual abuse were significantly associated with failing to achieve secondary school qualifications, but these associations lost significance after adjusting for social, parental, and individual factors [55]. The pathway from abuse to educational attainment is partially through performance at school. Learners who reported abuse and maltreatment were likely to perform poorly on tests, repeat grades, and encounter more problems with schoolwork [56,57].

Inextricably linked to incomplete schooling is unemployment, given that income poverty and inequality in South Africa are driven by disparities in qualifications and skills [58]. South Africa has an average unemployment rate of 34.4%, with youth unemployment (15–24-year-olds) at 64.4% and young adult unemployment (25–34-year-olds) at 42.9% [59]. Young adults in this study have similar rates of unemployment at 43.7%, risk factors for which were physical abuse, household death, and household substance abuse, as well as reporting six or more ACEs. A cross-sectional study looking at retrospective ACEs found that adults with four or more ACEs were 2.3 times more likely to be unemployed compared to adults with no ACEs [60], and other studies have linked early adversity to unemployment in similar ways [61–63]. Associations between ACEs and human capital outcomes such as unemployment and incomplete schooling are difficult to tease out given the high youth unemployment rates and poorly ranked education system in South Africa [64]. There is likely an interplay between exposure to ACEs and contextual and structural factors. For example, with a national dependency ratio of 52.7% and 70% (59% in 2003) of children living in households with at least one working adult [65], a household death may impact household income, ability to attend school, and subsequent employment. In fact, one study estimates that a 1 percentage point increase in school attendance is associated with an average decrease of 6 percentage points in the dependency ratio [66].

Sexual abuse in childhood is independently associated with welfare receipt in adulthood for females, as was inclusion in the *moderate adversity-abuse* and *high adversity* groups. General social protection measures in South Africa have made substantial contributions to poverty reduction [67], and the Child Support Grant in particular has had multiple benefits for vulnerable children and families [68–70]. Nevertheless, the receipt of the grant is a good indication that the household is income- and resource-poor [71].

HIV infection was also independently associated with sexual abuse in childhood for females. Prevalence of HIV positive status in the sample was 14%, mirroring the national population at 14% and below the 15–49-year-old age group at 20% [72]. A cross-sectional study among 2042 post-natal women in Harare, Zimbabwe found that 15% of the women tested positive, and that women who reported child sexual abuse were three times as likely to test positive for HIV [73]. The mechanisms for infection could operate directly, with infection occurring as a result of forced sex or rape, or indirectly through the weakening of psychological wellbeing and other protective factors that could lead to risky behaviors [74,75]. A South African study found that physical, sexual, and emotional abuse and neglect were associated with a range of HIV-risk behaviors [76].

Substance use in adulthood was associated with emotional abuse and exposure to violence in childhood, but only for males in the sample. Substance abuse has long been a global health challenge contributing to personal disability and mortality and economic burdens to society [77]. Studies in South Africa and worldwide have linked childhood trauma directly and indirectly, through mediation, to substance use in adulthood [78,79]. Furthermore, a recent meta-analysis suggests that individuals with four or more ACEs were twice as likely to be current smokers or heavy drinkers and six times as likely to drink problematically than those with no ACEs [7]. Criminality was linked to emotional abuse and exposure to IPV in childhood, as was inclusion in the *moderate adversity-abuse* and *high adversity* clusters. Females were almost three times more likely to engage in criminality if they reported six or more ACEs whereas males were 3–4 times more likely with more than one ACE. A study on siblings demonstrated that the likelihood of committing a crime doubled with experiences of child abuse and neglect [80]. Compared to females, relatively low levels of adversity could be linked to criminality in males; however, our analyses did not differentiate between serious and petty, or violent and non-violent crime, which may contribute to these differences. Findings in the literature are divergent, with some studies arguing for similar propensities for females and males to engage in serious, persistent, and violent crime [81], a study where males were at greater risk of committing a violent offense [82], and another where females were more likely to be arrested for violence [83]. The co-occurrence of substance use and criminality is well documented [84,85], and recent research has examined pathways showing that for moderate-to-high substance users, ACEs are linked to increased criminality [86]. These findings are interesting and may partly explain the sex differences in expressions of criminality.

4.2. Measuring ACEs

Comparing different approaches to ACEs measurement reveals several insights with regard to human capital outcomes. Individual ACEs, particularly prospective physical, sexual, and emotional abuse and exposure to violence can be linked to poorer outcomes. Retrospectively, these single ACEs, as well as household dysfunction indicators, are associated with poorer outcomes. Part of this may be that children may not be fully aware of household dysfunction and its extent or severity, as it occurs prospectively, and they may piece together these reports in hindsight. Alternatively, only those participants who experienced severe household dysfunction may be reporting so retrospectively. Another possibility is that prospective and retrospective measures of ACEs may be identifying different groups of individuals within a sample. Consequently, those identified as having greater ACEs prospectively may have different pathways to poor outcomes than those identified as having had greater ACEs retrospectively [22].

Cumulative measures of ACEs show graded relationships with gradual increases in risk for poor outcomes, demonstrating their ability to show the snowballing effect of ACEs. Clustered ACEs improve on these measures through their ability to make qualitative distinctions between ACEs that tend to co-occur. However, the usefulness of the ACEs score as a rapid screening tool should not be ignored. Cut-offs for ACE categories should be made in consideration with the distribution of ACEs among the population. The conventional cut-off at four ACEs in the five-level ACEs categories does not appear to be adequate

at distinguishing between those who are at a greater risk for poorer outcomes in high adversity settings. However, this five-level ACEs indicator, popularized by the CDC Kaiser study [10], appears to be more indicative of poorer outcomes when ACEs are assessed retrospectively compared to prospectively.

4.3. Implications of Findings

Single ACEs at the individual level—physical, sexual, and emotional abuse—have persistent and long-term impacts on a range of human capital outcomes. Exposure to high levels of adversity accumulated over childhood can lead to equally poor outcomes in adulthood. Patterns of ACEs can differentially predict human capital outcomes—the two distinct patterns are low-high and dysfunction-abuse. Individuals who fall into a *high adversity* category, characterized by generalized adversity across a range of indicators, are prone to poorer human capital outcomes. Prospectively, individuals with a high likelihood of abuse and the co-occurrence of household dysfunction in the form of IPV, chronic unemployment, and exposure to violence, are linked to adverse mental health. Retrospectively, emotional abuse and some household dysfunction can be linked to poorer human capital outcomes even in the absence of poverty proxied by chronic unemployment. Individual ACEs and a moderate amount of adversity may contribute to resilience and protect against certain poor human capital outcomes. Both individual and cumulative ACEs—the same type and number of ACEs—appear to affect males and females in different ways, leading to different outcomes. Therefore, demonstrating that disaggregation by sex is important. In further support of this, one study that assessed gendered profiles of adversity concluded that there are separate and distinct patterns of childhood adversities, with females experiencing more complex and varied patterns [29].

4.4. Strengths and Limitations

The Bt30 sample is situated in a previously disadvantaged urban area in South Africa, limiting the generalizability of findings. The prevalence of ACEs, both prospectively and retrospectively, is considerably higher than global and meta-analytic estimates [7]. However, ACEs evidence in low-income, high-violence settings with widespread adversity across the life course is slowly emerging [19,87–89] and highlighting important similarities and differences in the field. Bt30 is one of few cohorts in an LMIC that has reached young adulthood—the period in which human capital disparities are likely to emerge [90]. This cohort is also one of few with both prospective and retrospective data on ACEs, especially in LMIC contexts; comparisons between prospective and retrospective reports of ACEs are key to understanding the risk mechanisms that underlie poor outcomes. This is particularly true given limitations around self-reported retrospective data which can be open to social desirability bias, recall error and the like. The authors concede that the retrospective self-reports of ACEs may be exposed to such bias but counter that (a) self-reports may be closer to true estimates, taking into account unreported and unobserved adversity [91], and (b) that both self-reported retrospective and prospective measures of adversity show substantial links to poor outcomes [92], supporting the usefulness of these self-reported retrospective accounts of adversity.

5. Conclusions

The measurement of ACEs is more complicated than often assumed. Both timing—prospective and retrospective reports—and the approaches of measuring ACEs can give differing insights into their links to adverse outcomes. Consequently, thought needs to be given to how ACEs are used in practice and policy.

Given South Africa's strained economy—similar to other LMICs—it is critical that efforts are made to cultivate and protect human capital. The prevention of abuse in childhood—physical, sexual, and emotional abuse—must be a priority. Families need to be supported to mitigate the effects of household dysfunction. Evans and Kim suggest that "cumulative rather than singular exposure to a confluence of psychosocial and physical

environmental risk factors is a potentially critical aspect of the environment of childhood poverty" (p. 77) [93]. For resource-poor countries, understanding the potential impact of early adversity across the life course is critical to breaking the intergenerational cycle of poverty.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/ijerph19031799/s1, Table S1: Adverse childhood experiences questionnaire; Table S2: Model fit indices for latent class analysis of prospective and retrospective ACEs; Table S3: Crude associations between single, cumulative and clustered prospective ACEs and health and human capital outcomes; Table S4: Crude associations between single, cumulative and clustered retrospective ACEs and health and human capital outcomes; Table S5: Adjusted associations between single, cumulative and clustered prospective ACEs and health and human capital outcomes; Table S6: Adjusted associations between single, cumulative and clustered retrospective ACEs and health and human capital outcomes; Table S7: Adjusted associations between single, cumulative and clustered prospective ACEs and health and human capital outcomes, by sex; Table S8: Adjusted associations between single, cumulative and clustered retrospective ACEs and health and human capital outcomes, by sex.

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Institutional Review Board Statement: The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Witwatersrand University Committee for Research on Human Subjects (Ref. No. M010556, 2017).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Bt30 is housed in the DSI-NRF Centre of Excellence in Human Development at the University of the Witwatersrand and requests for data can be made through https://www.wits.ac.za/coe-human/open-access-datasets/ (accessed on 15 January 2022). Alternatively, the corresponding author of the study can be contacted for access to the data.

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Abbreviations

ACEs	Adverse Childhood Experiences
AIC	Akaike's Information Criteria
BIC	Baysian Information Criteria
Bt30	Birth to Thirty
CI	Confidence intervals
DSI-NRF	Department of Science and Innovation-National Research Foundation
HIV	Human immunodeficiency virus
IPV	Intimate partner violence
LCA	Latent class analysis
LMIC	Lower-middle-income country
OR	Odds ratios
SSABIC	Sample-size adjusted Bayesian Information Criteria

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Appendix 4: Declaration of contribution to articles

Declaration: Student's contribution to article(s) and agreement of co-author(s)

I, Sara Naicker, student number 866956, declare that this Thesis is my own work and that I contributed adequately towards research findings published in the article(s) stated below which are included in my Thesis.

Signature of Student:  **Date**: 24/03/2021

Name of Primary Supervisor: Professor Shane Norris

Signature of Primary Supervisor:  **Date**: 24/03/2021

Agreement by co-authors: By signing this declaration, the co-authors listed below agree to the use of the article by the student as part of her Thesis. In cases where the student is not the 1st author of a published article, the primary supervisor must explain (under comments) why the student is entitled to use the paper for his/her degree purposes.

Article 1: An analysis of retrospective and repeat prospective reports of adverse childhood experiences from the South African Birth to Twenty Plus cohort.

Journal name, year, volume and page numbers: Plos ONE, 12(7): e0181522. https://doi.org/10.1371/journal.pone.0181522

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3rd author	Musawenkosi Mabaso		26 March 2022
4th author	Linda Richter		24 March 2022

Article 2: Secondary analysis of retrospective and prospective reports of adverse childhood experiences and mental health in young adulthood: Filtered through recent stressors.

Journal name, year, volume and page numbers: eClinical Medicine, 40 (2021) 101094. https://doi.org/10.1016/j.eclinm.2021.101094

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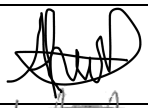
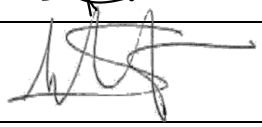
1st author	Sara N. Naicker		24 March 2022
2nd author	Shane N. Norris		24 March 2022
3rd author	Linda M. Richter		24 March 2022

Article 3: The long-term health and human capital consequences of adverse childhood experiences in the Birth to Thirty cohort: single, cumulative and clustered adversity.

Journal name, year, volume and page numbers: International Journal of Environmental Research and Public Health, 19, 1799. https://doi.org/10.3390/ ijerph19031799

Authors	Name	Signature	Date
1st author	Sara N. Naicker		24 March 2022
2nd author	Marilyn N. Ahun		25 March 2022
3rd author	Sahba Besharati		24 March 2022
4th author	Shane A Norris		24 March 2022
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6th author	Linda M. Richter		24 March 2022

Appendix 5: Adverse childhood experiences and recent stressors survey questions

Adverse childhood experiences: Thinking back to your childhood, the first 18 years of your life, please tick each one that applies to you			
ACE	**Question**	**Yes**	**No**
Physical abuse	Did a parent or other adult in the household **often or very often**…		
	Push, grab, slap, or throw something at you?		
	OR		
	Ever hit you so hard that you had marks or were injured?		
Sexual abuse	Did an adult or person at least 5 years older than you **ever**…		
	Touch or fondle you or have you touch their body in a sexual way?		
	OR		
	Attempt or actually have oral, anal, or vaginal intercourse with you?		
Emotional abuse	Did a parent or other adult in the household **often or very often**…		
	Swear at you, insult you, put you down, or humiliate you?		
	OR		
	Act in a way that made you afraid that you might be physically hurt?		
Emotional neglect	Did you **often or very often** feel that …		
	No one in your family loved you or thought you were important or special?		
	OR		
	Your family didn't look out for each other, feel close to each other, or support each other?		
Physical neglect	Did you **often or very often** feel that …		
	You didn't have enough to eat, had to wear dirty clothes, and had no one to protect you?		
	OR		
	Your parents were too drunk or high to take care of you or take you to the doctor if you needed it?		
Parental divorce	Were your parents **ever** separated or divorced?		

Adverse childhood experiences: Thinking back to your childhood, the first 18 years of your life, please tick each one that applies to you	
Witnessing domestic violence	Was your mother or stepmother: **Often or very often** pushed, grabbed, slapped, or had something thrown at her? **OR** **Sometimes, often, or very often** kicked, bitten, hit with a fist, or hit with something hard? **OR** **Ever** repeatedly hit at least a few minutes or threatened with a gun or knife?
Alcohol and/or drug abuse in the household	Did you live with anyone who was a problem drinker or alcoholic or who used street drugs?
Mental illness in the household	Was a household member depressed or mentally ill, or did a household member attempt suicide?
Legal trouble in the household	Did a household member go to prison?
Chronic illness (other than mental illness) in the household	Was there anyone in your household who was chronically ill when you were a child?
Unemployment of parent/caregiver	Was one or more of your parents/caregivers mostly unemployed during your childhood because they could not get a job?
Death of parent/caregiver	Did either of your parents/caregivers pass away before you turned 18?

Appendix 6: Physical and mental health and social outcomes survey questions

GHQ – at year 22

I am now going to ask you the General Health Questionnaire (GHQ 28) We would like to know if you have had any medical complaints and how your health has been in general, **over the past few weeks**.

Please answer ALL the
questions on the following pages simply by ticking the answer which you think most nearly applies to you. Remember that we want to know about present and recent complaints, not those that you had in the past.

Have you recently,

A1	Been feeling perfectly well and in good health?	Better than usual	Same as usual	Worse than usual	Much worse than usual
A2	Been feeling in need of a good tonic?	Not at all	No more than usual	Rather more than usual	Much more than usual
A3	Been feeling run down and out of sorts?	Not at all	No more than usual	Rather more than usual	Much more than usual
A4	Felt that you are ill?	Not at all	No more than usual	Rather more than usual	Much more than usual
A5	Been getting any pains in your head?	Not at all	No more than usual	Rather more than usual	Much more than usual
A6	Been getting a feeling of tightness or pressure in your head?	Not at all	No more than usual	Rather more than usual	Much more than usual
A7	Been having hot or cold spells?	Not at all	No more than usual	Rather more than usual	Much more than usual

Have you recently,

B1	Lost much sleep over worry?	Not at all	No more than usual	Rather more than usual	Much more than usual
B2	Had difficulty in staying asleep once you fall off "to sleep"?	Not at all	No more than usual	Rather more than usual	Much more than usual
B3	Felt constantly under strain?	Not at all	No more than usual	Rather more than usual	Much more than usual
B4	Been getting edgy and bad tempered?	Not at all	No more than usual	Rather more than usual	Much more than usual
B5	Been getting scared or panicky for no good reason?	Not at all	No more than usual	Rather more than usual	Much more than usual
B6	Found everything getting on top of you?	Not at all	No more than usual	Rather more than usual	Much more than usual
B7	Been feeling nervous and strung- out all the time?	Not at all	No more than usual	Rather more than usual	Much more than usual

Have you recently,

C1	Been managing to keep yourself busy and occupied?	More so than usual	Same as usual	Rather less than usual	Much less than usual
C2	Been taking longer to do the things you do?	Quicker than usual	Same as usual	Longer than usual	Much longer than usual
C3	Felt on the whole you were doing things well?	Better than usual	About the same as usual	Less well than usual	Much less well than usual
C4	Been satisfied with the way you've carried out your tasks?	More satisfied than usual	About the same as usual	Less satisfied than usual	Much less than usual
C5	Felt that you are playing a useful part in things?	More so than usual	Same as usual	Less so than usual	Much less than usual
C6	Felt capable of making decisions about things?	More so than usual	Same as usual	Rather less than usual	Much less than usual
C7	Been able to enjoy your normal day-to-day activities?	More so than usual	Same as usual	Rather less than usual	Much less than usual

Have you recently,

D1	Been thinking of yourself as a worthless person?	Not at all	No more than usual	Rather more than usual	Much more than usual
D2	Felt that life is entirely hopeless?	Not at all	No more than usual	Rather more than usual	Much more than usual
D3	Felt that life isn't worth living?	Not at all	No more than usual	Rather more than usual	Much more than usual
D4	Thought of the possibility that you might "make away" with yourself?	Definitely not	I don't think so	Has crossed my mind	Definitely have
D5	Found at times you couldn't do anything because your nerves were too bad?	Not at all	No more than usual	Rather more than usual	Much more than usual
D6	Found yourself wishing you were dead and away from it all?	Not at all	No more than usual	Rather more than usual	Much more than usual
D7	Found that the idea of taking your own life kept coming into your mind?	Definitely not	I don't think so	Has crossed my mind	Definitely have

Human capital outcomes at year 28

Employment		
Do you currently have a job? By job, we mean any work done to earn money including casual and informal work and internships.	Yes	No
Did you have a contract?	Yes	No
Education		
What is the highest grade you have passed? Recorded in 'Grade'	Coded as completed matric	Coded as not completed matric
Welfare receipt		
Official government statistics on receipt of the Child Support Grant	Yes	No
Criminality		
During the last year, did you steal something from a shop or store?	Yes	No
During the last year, did you damage or destroy property that did not belong to you on purpose (e.g. windows, cars, or street lights)?	Yes	No
During the last year, did you break into a car or motorbike to try and steal something out of it?	Yes	No
During the last year, did you steal a car or motorbike?	Yes	No
During the last year, did you sell illegal drugs to someone?	Yes	No
During the last year, did you break into a house or building to try and steal something?	Yes	No
During the last year, did you hit, kick, punch, or attack someone with the intention of really hurting them? (This DOES NOT include brothers, sisters, or play fighting)	Yes	No
During the last year, did you set	Yes	No
During the last year, did you carry a knife or other weapon with you for protection or in case it was needed in a	Yes	No
Did you actually use a weapon against somebody in the last year?	Yes	No
During the last year, did you have sex with someone by force or against their will?	Yes	No
During the last year, have you been a member of a gang?	Yes	No
Mental health		
In the past month, did you often have headaches?	Yes	No
In the past month, was your appetite poor?	Yes	No
In the past month, did you sleep badly?	Yes	No
In the past month, were you easily frightened?	Yes	No
In the past month, did your hands shake?	Yes	No
In the past month, did you feel nervous, tense or worried?	Yes	No

In the past month, was your digestion poor?	Yes	No
In the past month, did you have trouble thinking clearly?	Yes	No
In the past month, did you feel unhappy?	Yes	No
In the past month, did you cry more than usual?	Yes	No
In the past month, did you find it difficult to enjoy your daily activities?	Yes	No
In the past month, did you find it difficult to make decisions?	Yes	No
In the past month, was your daily work painful and causes you suffering?	Yes	No
In the past month, were you unable to play a useful part in life?	Yes	No
In the past month, did you lose interest in things?	Yes	No
In the past month, did you feel that you are a worthless person?	Yes	No
In the past month, has the thought of ending your life been on your mind?	Yes	No
In the past month, did you feel tired all the time?	Yes	No
In the past month, did you have uncomfortable feelings in your stomach?	Yes	No
In the past month, were you easily tired?	Yes	No
Social isolation		
In the past month please describe how often you had someone who understood your problems	1 Never 2 Rarely 3 Sometimes 4 Usually 5 Always	
In the past month please describe how often you had someone who would listen to you when you needed to talk radio	1 Never 2 Rarely 3 Sometimes 4 Usually 5 Always	
In the past month please describe how often you felt there were people you could talk to if you were upset	1 Never 2 Rarely 3 Sometimes 4 Usually 5 Always	
In the past month please describe how often you had someone to talk with when you had a bad day	1 Never 2 Rarely 3 Sometimes 4 Usually 5 Always	
In the past month please describe how often you had someone you trust to talk with about your problems	1 Never 2 Rarely 3 Sometimes	

	4 Usually 5 Always	
In the past month please describe how often you had someone you trust to talk with about your feelings	1 Never 2 Rarely 3 Sometimes 4 Usually 5 Always	
In the past month please describe how often you could get helpful advice from others when dealing with a problem	1 Never 2 Rarely 3 Sometimes 4 Usually 5 Always	
In the past month please describe how often you had someone to turn to for suggestions about how to deal with a problem	1 Never 2 Rarely 3 Sometimes 4 Usually 5 Always	
Substance abuse		
How often do you drink beer, wine, or spirits?	1 Never 2 Monthly or less 3 2 to 4 times a month 4 2 to 3 times a week 5 4 or more times a week	
Have you ever used drugs (including marijuana) other than those required for medical reasons?	Yes	No
Do you currently use drugs (including marijuana) other than those required for medical reasons?	Yes	No
HIV infection		
Have you ever tested positive for HIV	Yes	No

Appendix 7: Ethics clearance certificates

UNIVERSITY OF THE
WITWATERSRAND,
JOHANNESBURG

R14/49 Ms Sara Naicker

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M140726

NAME: (Principal Investigator)	Ms Sara Naicker
DEPARTMENT:	School of Clinical Medicine Paediatrics Developmental Pathways for Health Research Unit
PROJECT TITLE:	Adverse Childhood Experiences and Social and Health Outcomes in Later Life
DATE CONSIDERED:	25/07/2014
DECISION:	Approved unconditionally
CONDITIONS:	
SUPERVISOR:	Professor Shane Norris
APPROVED BY:	Professor P Cleaton-Jones, Chairperson, HREC (Medical)
DATE OF APPROVAL:	05/10/2016

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office Secretary in Room 301, Third floor, Faculty of Health Sciences, Phillip Tobias Building, 29 Princess of Wales Terrace, Parktown, 2193, University of the Witwatersrand. I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated, from the research protocol as approved, I/we undertake to resubmit the application to the Committee. **I agree to submit a yearly progress report**. The date for annual re-certification will be one year after the date of convened meeting where the study was initially reviewed. In this case, the study was initially reviewed September and will therefore be due in the month of September each year. Unreported changes to the application may invalidate the clearance given by the HREC (Medical).

Principal Investigator Signature

9 October 2016
Date

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Division of the Deputy Registrar (Research)

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
R14/49 Professor Shane Norris

CLEARANCE CERTIFICATE	M111182
PROJECT	Birth to Twenty Plus, Investigation into Young Adult Health
INVESTIGATORS	Professor Shane Norris
DEPARTMENT	Department of Paediatrics
DATE CONSIDERED	25/11/2011
DECISION OF THE COMMITTEE*	Approved unconditionally

Unless otherwise specified this ethical clearance is valid for 5 years and may be renewed upon application.

DATE 25/03/2014 **CHAIRPERSON** .....
(Professor P E Cleaton Jones)

*Guidelines for written 'informed consent' attached where applicable

cc: Supervisor : Prof Shane Norris

DECLARATION OF INVESTIGATOR(S)

To be completed in duplicate and **ONE COPY** returned to the Secretary at Room 10004, 10th Floor, Senate House, University.
I/We fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee. **I agree to a completion of a yearly progress report.**

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

UNIVERSITY OF THE WITWATERSRAND JOHANNESBURG

R14/49 Professor L Richter

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
CLEARANCE CERTIFICATE NO. M1811136

NAME: (Principal Investigator)	Professor L Richter
DEPARTMENT:	DST-NRF Centre of Excellence in Human Development Office of the DVC (Research) & Postgraduate Affairs
PROJECT TITLE:	Birth-to-20+ Human Capital Study
DATE CONSIDERED:	Ad hoc
DECISION:	Approved unconditionally
CONDITIONS:	Sub-study under M180225 Approval encompasses educational attainments and receipt of social grants
SUPERVISOR:	Not applicable
APPROVED BY:	Dr CB Penny, Chairperson HREC (Medical)
DATE OF APPROVAL:	14/01/2019

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office Secretary on 3rd floor, Phillip V Tobias Building, Parktown, University of the Witwatersrand, Johannesburg.

I/We fully understand the conditions under which I am/we are authorised to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated from the research protocol as approved, I/we undertake to resubmit to the Committee. **I agree to submit a yearly progress report.** When a funder requires annual re-certification, the application date will be one year after the date of the meeting when the study was initially reviewed. In this case, the study was initially reviewed in **November** and will therefore reports and re-certification will be due early in the month of **November** each year. Unreported changes to the application may invalidate the clearance given by the HREC (Medical).

Principal Investigator Signature

15th Jan 2019
Date

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

Appendix 8: Supplementary material to Chapter 4: Secondary analysis of retrospective and prospective reports of adverse childhood experiences and mental health in young adulthood: Filtered through recent stressors

Table 4A. Missing data on variables used in the study

Variable	No. Valid observations	No. missing observations	% missing observations
Exposures			
Prospective ACE report	1592	0	0
Retrospective ACE report	1592	0	0
Outcomes			
Somatization	1574	18	1·13
Anxiety	1574	18	1·13
Social dysfunction	1575	17	1·07
Depression	1574	18	1·13
GHQ total	1536	56	3·52
Covariates			
Sex	1589	3	0·19
Ethnicity	1589	3	0·19
Socio-economic status	1466	126	7·91
Maternal education	1476	116	7·29
Negative recent life events	1558	34	2·14

ACE scores were computed for each participant who had data for at least 10 of the 13 ACEs; those with fewer than 10 – or 3 or more missing data points – were excluded from the analytic dataset. For prospective data, missing data was imputed from previous and subsequent waves of data to compose comprehensive accounts. The analysis was restricted to cases with data on the exposures, only cases with data for both prospective and retrospective ACEs were included.

Table 4B: Comparison of the distribution of prospective and retrospective ACEs between cases with data and those without for variables included in the study

Variable	Prospective ACEs						Retrospective ACEs					
	None	One	Two	Three	≥ Four	p value	None	One	Two	Three	≥ Four	p value
Outcomes												
Somatization						0·59						0·00
No distress	6 (0·6)	17 (1·7)	23 (2·3)	79 (7·8)	887 (87·6)		99 (9·8)	208 (20·6)	180 (17·8)	171 (16·9)	354 (35·0)	
Distress	2 (0·4)	7 (1·3)	22 (3·9)	40 (7·1)	491 (87·4)		31 (5·5)	64 (11·4)	111 (19·8)	108 (19·2)	248 (44·1)	
Missing	0 (0·0)	2 (11·0)	1 (5·6)	1 (5·6)	14 (77·8)		9 (50·0)	5 (27·8)	2 (11·1)	0 (0·0)	2 (11·1)	
Anxiety						0·02						0·00
No distress	3 (0·3)	17 (1·8)	20 (2·1)	73 (7·7)	831 (88·0)		95 (10·1)	205 (21·7)	193 (19·4)	167 (17·7)	294 (31·1)	
Distress	5 (0·8)	7 (1·1)	25 (4·0)	46 (7·3)	547 (86·8)		35 (5·6)	67 (10·6)	108 (17·1)	112 (17·8)	308 (48·9)	
Missing	0 (0·0)	2 (11·1)	1 (5·6)	1 (5·6)	14 (77·8)		9 (50·0)	5 (27·8)	2 (11·1)	0 (0·0)	2 (11·1)	
Social dysfunction						0·06						0·00
No distress	3 (0·5)	10 (1·5)	14 (2·1)	55 (8·4)	576 (87·5)		57 (8·7)	127 (19·3)	106 (16·1)	120 (16·2)	248 (37·7)	
Distress	5 (0·6)	14 (1·5)	31 (3·4)	64 (7·0)	803 (87·6)		73 (8·0)	145 (15·8)	185 (20·1)	159 (17·3)	355 (38·7)	
Missing	0 (0·0)	2 (11·8)	1 (5·9)	1 (5·9)	13 (76·5)		9 (52·9)	5 (29·4)	2 (11·8)	0 (0·0)	1 (5·9)	
Depression						0·02						0·00
No distress	7 (0·5)	21 (1·6)	36 (2·7)	110 (8·3)	1160 (87·0)		119 (8·9)	247 (18·5)	257 (19·3)	242 (19·1)	469 (35·2)	
Distress	1 (0·4)	3 (1·3)	9 (3·8)	9 (3·8)	218 (90·8)		11 (4·6)	25 (10·4)	34 (14·2)	37 (15·4)	133 (55·4)	
Missing	0 (0·0)	2 (11·1)	1 (5·6)	1 (5·6)	14 (77·8)		9 (50·0)	5 (27·8)	2 (11·1)	0 (0·0)	2 (11·1)	
GHQ total						0·14						0·00
No distress	5 (0·4)	21 (1·9)	27 (2·4)	92 (8·2)	983 (87·2)		110 (9·8)	232 (20·6)	211 (18·7)	202 (17·9)	373 (33·1)	
Distress	2 (0·5)	3 (0·7)	18 (4·4)	24 (5·9)	361 (85·7)		20 (4·9)	37 (9·1)	74 (18·1)	72 (17·9)	205 (50·3)	
Missing	1 (1·8)	2 (3·6)	1 (1·8)	4 (7·1)	48 (85·7)		9 (16·1)	8 (14·3)	8 (14·3)	5 (8·9)	26 (46·3)	
Covariates												
Sex						0·00						0·01
Male	3 (0·4)	12 (1·6)	13 (1·7)	55 (7·2)	681 (89·1)		61 (8·0)	132 (17·3)	113 (14·8)	138 (18·1)	320 (41·9)	
Female	5 (0·6)	14 (1·7)	31 (3·76)	65 (7·9)	710 (86·1)		78 (9·5)	145 (17·6)	179 (21·7)	140 (17·0)	283 (34·3)	
Missing	0 (0·0)	0 (0·0)	2 (66·7)	0 (0·0)	1 (33·3)		0 (0·0)	0 (0·0)	1 (33·3)	1 (33·3)	1 (33·3)	
Ethnicity						0·00						0·76
White	0 (0·0)	0 (0·0)	0 (0·0)	0 (0·0)	1 (100·0)		0 (0·0)	0 (0·0)	1 (100·0)	0 (0·0)	0 (0·0)	
Black	5 (0·4)	24 (1·7)	39 (2·7)	107 (7·4)	1266 (87·9)		124 (8·6)	248 (17·2)	262 (18·2)	257 (17·8)	550 (38·2)	
Mixed	2 (1·5)	2 (1·5)	3 (2·2)	11 (8·2)	116 (86·6)		12 (9·0)	27 (20·2)	26 (19·4)	19 (14·2)	50 (37·3)	
Indian	1 (7·69)	0 (0·0)	2 (15·4)	2 (15·4)	8 (61·5)		3 (23·1)	2 (15·4)	3 (23·1)	2 (15·4)	3 (23·1)	
Missing	0 (0·0)	0 (0·0)	2 (66·7)	0 (0·0)	1 (33·3)		0 (0·0)	0 (0·0)	1 (33·3)	1 (33·3)	1 (33·3)	
Socio-economic status						0·15						
Quintile 1	0 (0·0)	4 (1·8)	6 (2·7)	20 (8·9)	195 (86·7)		14 (6·2)	37 (16·4)	31 (13·8)	41 (18·2)	102 (45·3)	0·08
Quintile 2	2 (0·7)	5 (1·9)	5 (1·9)	14 (5·2)	243 (90·3)		23 (8·6)	39 (15·5)	53 (19·7)	48 (17·8)	106 (39·4)	
Quintile 3	1 (0·2)	3 (0·6)	17 (3·3)	38 (7·4)	452 (88·5)		39 (7·6)	93 (18·2)	95 (18·6)	89 (17·4)	195 (38·2)	
Quintile 4	3 (1·0)	6 (2·0)	5 (1·7)	22 (7·4)	261 (87·8)		32 (10·8)	56 (18·9)	62 (20·9)	43 (14·5)	104 (35·0)	
Quintile 5	1 (0·6)	4 (2·4)	6 (3·7)	20 (12·2)	133 (81·1)		18 (11·0)	33 (20·1)	34 (20·7)	37 (22·6)	42 (25·6)	
Missing	1 (0·8)	4 (3·2)	7 (5·6)	6 (4·8)	108 (85·7)		13 (10·3)	19 (15·1)	18 (14·3)	21 (16·7)	55 (43·7)	
Maternal education						0·02						0·02
No formal	0 (0·0)	2 (1·0)	3 (1·6)	16 (8·3)	172 (89·1)		15 (7·8)	37 (19·2)	29 (15·0)	38 (19·7)	74 (38·3)	

Variable	Prospective ACEs						Retrospective ACEs					
	None	One	Two	Three	≥ Four	p value	None	One	Two	Three	≥ Four	p value
Primary	0 (0·0)	5 (0·7)	19 (2·8)	52 (7·6)	611 (88·9)		42 (6·1)	111 (16·2)	127 (18·5)	118 (17·2)	289 (42·1)	
Secondary	5 (1·0)	16 (3·3)	14 (2·9)	32 (6·5)	425 (86·4)		55 (11·2)	90 (18·3)	103 (20·9)	86 (17·5)	158 (32·1)	
Tertiary	2 (1·9)	2 (1·9)	4 (3·9)	11 (10·6)	85 (81·7)		15 (14·4)	22 (21·2)	47 (13·5)	18 (17·3)	35 (33·7)	
Missing	1 (0·9)	1 (0·9)	6 (5·2)	9 (7·8)	99 (85·3)		12 (10·3)	17 (14·7)	20 (17·2)	19 (16·4)	48 (41·4)	
Negative recent life events						0·01						0·00
None	3 (0·6)	10 (2·1)	26 (5·6)	40 (8·6)	389 (83·1)		84 (18·0)	136 (29·1)	96 (20·5)	69 (14·7)	83 (17·7)	
One	3 (0·7)	8 (1·9)	6 (1·5)	40 (9·7)	357 (86·2)		30 (7·3)	75 (18·1)	110 (26·6)	67 (16·2)	132 (31·9)	
Two	1 (0·3)	3 (1·6)	3 (1·6)	13 (6·8)	170 (89·5)		10 (3·3)	35 (11·4)	50 (16·3)	71 (23·2)	140 (45·8)	
Three	1 (0·5)	3 (1·6)	3 (1·6)	13 (6·8)	170 89·5)		3 (1·6)	12 (6·3)	19 (10·0)	44 (23·2)	112 (59·0)	
≥ Four	0 (0·0)	0 (0·0)	2 (1·1)	10 (5·6)	168 (93·3)		1 (0·6)	7 (3·9)	15 (8·3)	24 (13·3)	133 (73·9)	
Missing	0 (0·0)	1 (2·9)	3 (8·8)	1 (2·9)	29 (85·3)		11 (32·4)	12 (35·3)	3 (8·8)	4 (11·8)	4 (11·8)	

Significant *p* values are reflective of the small number of missing cases in each cell, biasing the distribution across ACEs.

Table 4C. Factorial ANOVA examining effects of retrospective and prospective ACEs and recent stressors on psychological distress

Source	Sum of squares	*df*	Mean Square	*F*	*p*	Eta^2
Prospective ACEs, recent stressors and prospective ACEs by recent stressors (N=1515, R^2 = 0·0475, Adj· R^2 = 0·0418)						
Model	11161·92	9	1240·21	8·35	·0000	·0475
Recent stressors	9344·04	4	2336·01	15·72	·0000	·0401
Prospective ACEs	777·59	1	774·59	5·21	·0226	·0034
Prospective ACEs x Recent stressors	497·92	4	124·48	0·84	·5012	·0022
Residual	223645·07	1505	148·60			
Retrospective ACEs, recent stressors and retrospective ACEs by recent stressors N=1515, R^2 = 0·0696, Adj· R^2 = 0·0546						
Model	13388·86	9	1487·65	10·11	·0000	·0570
Recent stressors	4149·19	4	1037·29	7·05	·0000	·0183
Retrospective ACEs	3218·75	1	3218·75	21·88	·0000	·0143
Retrospective ACEs x Recent stressors	69·32	4	17·33	0·12	·9762	·0003
Residual	221418·12	1505				
Prospective ACES, retrospective ACEs and prospective by retrospective ACEs on somatization N=1574, R^2 = 0·0135, Adj· R^2 = 0·0117						
Model	334·67	3	111·56	7·18	·0001	·0135
Prospective ACEs	16·80	1	16·80	1·08	·2985	·0006
Retrospective ACEs	272·91	1	272·91	17·57	·0000	·0110
Prospective ACEs x Retrospective ACEs	9·96	1	9·96	0·64	·4234	·0004
Residual	24380·01	1570	15·53			
Prospective ACES, retrospective ACEs and prospective by retrospective ACEs on anxiety N=1574, R^2 = 0·0461, Adj· R^2 = 0·0443						
Model	1864·94	3	621·61	25·31	·0000	·4613
Prospective ACEs	10·25	1	10·25	0·42	·5184	·0003
Retrospective ACEs	1717·10	1	1717·10	69·91	·0000	·0426
Prospective ACEs x Retrospective ACEs	16·19	1	16·19	0·66	·4168	·0004
Residual	38560·62	1570	24·56			
Prospective ACES, retrospective ACEs and prospective by retrospective ACEs on social dysfunction N=1575, R^2 = 0·0009, Adj· R^2 = 0·0010						
Model	15·39	3	5·13	0·45	·7160	·0008
Prospective ACEs	4·74	1	4·75	0·42	·5180	·0002
Retrospective ACEs	5·09	1	5·09	0·45	·5035	·0002
Prospective ACEs x Retrospective ACEs	1·29	1	1·29	0·11	·7361	·0000
Residual	17842·40	1571	11·36			
Prospective ACES, retrospective ACEs and prospective by retrospective ACEs on depression N=1574, R^2 = 0·0475, Adj· R^2 = 0·0457						
Model	1150·77	3	383·59	26·13	·0000	·0475
Prospective ACEs	286·90	1	286·90	19·54	·0000	·0122
Retrospective ACEs	630·87	1	630·87	42·97	·0000	·0266
Prospective ACEs x Retrospective ACEs	59·65	1	59·65	4·06	·0440	·0026
Residual	23050·76	1570	14·68			
Prospective ACES, retrospective ACEs and prospective by retrospective ACEs on total GHQ N=1536, R^2 = 0·0390, Adj· R^2 = 0·0371						
Model	9236·22	3	3078·74	20·73	·0000	·0390
Prospective ACEs	605·85	1	605·85	4·08	·0436	·0027
Retrospective ACEs	7275·73	1	7575·43	48·98	·0000	·0309
Prospective ACEs x Retrospective ACEs	209·03	1	209·03	1·41	·2357	·0009
Residual	227569·22	1532	148·54			

Factorial analysis of variance showing unique contribution of prospective and retrospective reports of ACEs, as well as any interactions between them, to the variance in each mental health outcome as well as for the interaction effects between retrospectively and prospectively reported ACEs and recent stressors on psychological distress.

Table 4D. Unadjusted effects of reported ACEs on mental health

		Somatization OR [CI 95%]	Anxiety OR [CI 95%]	Social dysfunction OR [CI 95%]	Depression OR [CI 95%]	GHQ Total OR [CI 95%]
Prospective ACEs						
Physical abuse		1·08 [·88-1·36]	1·18 [·95-1·47]	·89 [·72-1·11]	1·53 [1·13-2·09]**	1·23 [·96-1·58]
Sexual abuse		1·22 [·98-1·52]	1·06 [·86-1·32]	·92 [·74-1·14]	1·67 [1·25-2·24]**	1·34 [1·05-1·71]*
Emotional abuse/neglect		1·29 [1·04-1·62]*	1·32 [1·07-1·65]*	1·13 [·91-1·41]	1·17 [·87 1·57]	1·37 [1·08-1·76]**
Child separation		1·29 [·96-1·71]	1·18 [·88-1·57]	1·24 [·93-1·67]	1·04 [·71-1·55]	1·27 [·93-1·74]
Divorce/separation		·89 [·72-1·11]	·94 [·77-1·17]	·99 [·80-1·21]	·99 [·75-1·33]	·89 [·70-1·13]
Parental death		·88 [·68-1·13]	·94 [·73-1·21]	1·12 [·87-1·44]	1·23 [·89-1·71]	1·10 [·83-1·45]
Exposure to violence		1·08 [·84-1·41]	·81 [·63-1·04]	1·01 [·78-1·30]	1·04 [·72-1·49]	1·00 [·75-1·33]
Exposure to IPV		·88 [·69-1·12]	1·15 [·91-1·46]	·93 [·73-1·17]	·99 [·72-1·37]	·91 [·70-1·19]
Chronic unemployment		·69 [·49-·98]*	·70 [·50-·96]*	·66 [·47-·93]*	·73 [·47-1·14]	·71 [·50-1·02]
Household substance abuse		·97 [·78-1·21]	·94 [·76-1·16]	1·06 [·86-1·31]	1·05 [·79-1·41]	·99 [·78-1·26]
Household legal trouble		·90 [·72-1·13]	·93 [·74-1·16]	·94 [·76-1·17]	1·23 [·92-1·66]	·99 [·78-1·27]
Household illness/disability		·97 [·77-1·22]	·95 [·76-1·16]	1·14 [·92-1·43]	1·05 [·77-1·44]	1·02 [·79-1·32]
Household death		1·04 [·83-1·31]	1·07 [·86-1·34]	·97 [·78-1·21]	1·15 [·84-1·56]	1·13 [·88-1·46]
Pros ACE category	0 (ref)					
	1	1·24 [·19-7·67]	·25 [·46-1·32]	·84 [·16-4·35]	1·01 [·09-11·24]	·36 [·05-2·74]
	2	2·9 [·25-15·77]	·75 [·16-3·52]	1·33 [·28-6·35]	1·75 [·19-16·09]	1·67 [·29-9·54]
	3	1·51 [·29-7·87]	·38 [·09-1·66]	·69 [·16-3·05]	·57 [·06-5·18]	·65 [·12-3·57]
	≥4	1·67 [·34-8·29]	·39 [·09-1·65]	·84 [·20-3·54]	1·3 [·16-10·86]	·92 [·18-4·76]
Binary Pros ACEs	Less than 4 (ref)					
	Four or more	1·84 [·64-2·27]**	1·08 [·88-1·32]	1·05 [·86-1·29]	1·69 [1·28-2·23]***	1·35 [1·07-1·69]*
Total Pros ACE score		1·00 [·96-1·05]	·99 [·96-1·04]	·99 [·95-1·03]	1·12 [1·06-1·19]***	1·05 [1·01-1·10]*
Retrospective ACEs						
Physical abuse		·89 [·52-·1·51]	1·77 [1·05-3·00]*	·91 [·55-1·52]	1·43 [·77-2·67]	1·7 [·67-2·07]
Sexual abuse		1·56 [·81-3·02]	2·15 [1·10-4·19]*	1·49 [·77-2·91]	1·98 [·90-4·34]	1·88 [·93-3·79]
Emotional abuse/neglect		1·10 [·79-1·52]	1·28 [1·04-1·76]*	·96 [·71-1·31]	1·56 [1·02-2·41]*	1·44 [1·01-2·05]*
Divorce/separation		·86 [·65-1·15]	·93 [·70-1·24]	·77 [·59-1·00]	1·39 [·94-2·07]	1·10 [·80-1·51]
Parental death		1·08 [·77-1·52]	·90 [·64-1·27]	1·03 [·75-1·43]	·99 [·62-1·57]	·95 [·65-1·39]
Exposure to violence		1·27 [·93-1·74]	1·38 [1·01-1·89]*	1·26 [·93-1·71]	1·17 [·77-1·79]	1·37 [·97-1·94]
Exposure to IPV		1·67 [1·12-2·51]*	1·52 [1·01-2·03]*	1·82 [1·19-2·76]**	·84 [·49-1·46]	1·49 [·97-2·32]
Chronic unemployment		1·14 [·85-1·53]	1·21 [·90-1·61]	·79 [·59-1·05]	1·22 [·81-1·83]	·88 [·63-1·22]
Household substance abuse		1·40 [·99-1·97]	1·17 [·84-1·64]	1·13 [·82-1·57]	1·34 [·85-2·09]	1·37 [·95-1·98]
Household legal trouble		·78 [·54-1·10]	1·46 [1·04-2·07]*	1·10 [·78-1·55]	·88 [·55-1·42]	·84 [·56-1·24]
Household illness/disability		1·6 [1·19-2·17]**	1·57 [1·17-2·11]**	1·00 [·75-1·34]	1·75 [1·16-2·64]**	·135 [·97-1·88]
Household death		·89 [·66-1·21]	1·22 [·91-1·65]	1·09 [·82-1·45]	1·31 [·87-1·98]	1·34 [·97-1·87]
Retro ACE category	0 (ref)					
	1	·97 [·60-1·55]	·85 [·53-1·35]	·85 [·57-1·29]	1·03 [·51-2·07]	·80 [·45-1·40]
	2	1·87 [1·19-2·94]**	1·54 [·99-2·39]	1·28 [·85-1·94]	1·26 [·64-2·48]	1·74 [1·03-2·93]*
	3	1·91 [1·21-3·02]**	1·74 [1·12-2·72]*	·97 [·64-1·47]	1·46 [·75-2·84]	1·77 [1·05-2·98]*
	≥4	2·12 [1·39-3·23]***	2·73 [1·82-4·10]***	1·05 [·72-1·53]	2·70 [1·48-4·94]**	2·72 [1·69-4·39]***
Binary Retro ACEs	Less than four					
	More than four	1·47 [1·19-1·81]***	2·11 [1·72-2·6]***	1·04 [·85-1·28]	2·29 [1·74-3·03]***	2·04 [1·62-2·57]***
Total Retro ACE score		1·15 [1·11-1·21]***	1·26 [1·19-1·33]***	1·00 [·95-1·05]	1·21 [1·13-1·29]***	1·23 [1·16-1·29]***

Logistic regression models fitted for each individual ACE, followed by each composite measure of ACEs, separately for prospective and retrospective ACEs.
* p<·05 **p<·01 ***p<·0001

Table 4E. Adjusted effects of reported ACEs on mental health

		Somatization OR [CI 95%]	Anxiety OR [CI 95%]	Social dysfunction OR [CI 95%]	Depression OR [CI 95%]	GHQ Total OR [CI 95%]
Sex	(Male ref)					
	Female	2·18 [1·72-2·76]***	2·35 [1·84-3·01]***	1·51 [1·22-1·88]***	2·79 [1·99-3·89]***	2·63 [2·02-3·43]***
SES	(Quintile 1 ref)					
	Quintile 2	1·02 [·68-1·54]	·84 [·55-1·28]	·83 [·57-1·22]	1·09 [·65-1·84]	1·01 [·66-1·56]
	Quintile 3	1·03 [·72-1·48]	·88 [·61-1·28]	·83 [·59-1·75]	1·05 [·65-1·70]	·85 [·57-1·26]
	Quintile 4	·99 [·66-1·49]	·87 [·58-1·32]	·66 [·45-·97]*	1·07 [·62-1·84]	·97 [·63-1·59]
	Quintile 5	·84 [·61-1·58]	·98 [·64-1·67]	1·03 [·66-1·62]	1·01 [·53-1·93]	·96 [·57-1·60]
Maternal education	No schooling (ref)					
	Primary school	1·14 [·78-1·66]	1·09 [·74-1·60]	·80 [·56-·98]*	·96 [·60-1·54]	·90 [·60-1·35]
	Secondary school	1·18 [·79-1·76]	1·27 [·84-1·92]	·99 [·69-1·45]	·68 [·41-1·17]	1·05 [·68-1·62]
	Post-secondary	1·59 [·92-2·77]	1·39 [·79-2·46]	·79 [·47-1·34]	·85 [·39-1·82]	·99 [·54-1·84]
Recent stressors	0 (ref)					
	1	1·26 [·92-1·74]	1·55 [1·11-2·17]*	1·20 [·90-1·60]	·97 [·61-1·54]	1·02 [·71-1·47]
	2	1·54 [1·08-2·19]*	1·72 [1·18-2·51]**	1·43 [·99-1·96]	1·38 [·85-2·22]	1·71 [1·17-2·50]**
	3	2·09 [1·38-3·15]***	2·12 [1·36-3·30]**	1·23 [·85-1·77]	1·30 [·75-2·27]	1·98 [1·28-3·07]**
	≥4	2·26 [1·47-3·47]***	2·45 [1·50-4·12]***	1·11 [·76-1·62]	1·81 [1·05-3·13]*	2·5 [1·63-3·96]***
Prospective ACEs						
Physical abuse					1·67 [1·37-1·93]*	
Sexual abuse					1·79 [1·27-2·07]*	1·20 [·92-1·58]
Emotional abuse/neglect		1·17 [·91-1·48]	1·14 [·89-1·46]			1·25 [1·04-1·63]*
Chronic unemployment		·70 [·50-·99]*	·64 [·45-·91]*	·88 [·63-1·23]		
Binary Prospective ACEs	(<4 ref)					1·10 [·83-1·45]
	≥4	2·73 [1·42-3·53]**			1·30 [·91-1·86]	2·23 [1·58-3·12]**
Retrospective ACEs						
Physical abuse			1·83 [1·16-2·89]*			
Sexual abuse			1·47 [·81-2·65]			
Emotional abuse/neglect			1·76 [1·32-2·36]***		1·56 [1·08-2·25]*	1·60 [1·18-2·17]**
Exposure to IPV		1·71 [1·19-2·46]**	1·63 [1·12-2·37]*	1·29 [·92-1·82]		
Exposure to violence			1·13 [·82-1·55]			
Household illness/disability		1·48 [1·14-1·92]**	1·14 [·87-1·49]		1·19 [·84-1·69]	
Household legal trouble			1·32 [·97-1·79]			
Binary Retrospective ACEs	(<4 ref)					
	≥4	1·51 [1·14-2·06]**	1·91 [1·27-2·83]**		1·55 [1·07-2·31]*	1·94 [1·26-2·99]**

Adjusted logistic regression models with covariates sex, socioeconomic status, maternal education and recent stressors. Five separate models, one per outcome, are fitted with significant predictors from unadjusted models and include both prospective and retrospective ACEs; the ORs for prospective ACEs indicates the unique contribution of that predictor independently from retrospective ACEs and vice versa. Empty cells represent those predictors that were not entered into a model for that specific outcome.

* p<·05 **p<·01 ***p<·0001

Appendix 9: Supplementary material to Chapter 5: The Long-Term Health and Human Capital Consequences of Adverse Childhood Experiences in the Birth to Thirty Cohort: Single, Cumulative, and Clustered Adversity

Table 5A: Model fit indices for latent class analysis of prospective and retrospective ACEs

Number of classes	AIC	BIC	SSABIC	Entrophy	Smallest class
Prospective LCA					
Class 1	37452,01	37529,97	37488,66		
Class 2	35800,92	35962,84	35877,05	0,557	49,2
Class 3	35565,64	35811,51	35681,24	0,495	31,6
Class 4	35412,33	35742,17	35567,41	0,499	11,2
Class 5	35372,72	35786,51	35567,27	0,464	10,2
Class 6	35354,67	35852,42	35588,70	0,493	4,3
Retrospective LCA					
Class 1	18434,05	18499,91	18461,79		
Class 2	16348,06	16485,28	16405,86	0,797	33,7
Class 3	16156,52	16365,09	16244,37	0,688	13,0
Class 4	16018,37	16298,30	16136,28	0,632	12,0
Class 5	16013,32	16364,61	16161,29	0,663	1,8
Class 6	16015,12	16437,76	16193,14	0,647	1,8

Table 5B: Crude associations between single, cumulative and clustered prospective ACEs and health and human capital outcomes

	Psychological distress	Social isolation	Incomplete schooling	Unemployed	Substance use	HIV infection	Welfare receipt	Criminality
Single ACEs								
Physical abuse	1.18 [.85-1.64]	1.20 [.80-1.79]	1.73 [1.28-2.33]***	1.38 [1.08-1.76]**	1.03 [.76-1.40]	1.31 [.86-1.98]	1.28 [.92-1.78]	.88 [.60-1.27]
Sexual abuse	1.01 [.72-1.40]	.71 [.47-1.09]	1.74 [1.35-2.24]***	1.36 [1.05-1.77]*	.84 [.62-1.14]	1.47 [1.03-2.10]*	1.56 [1.16-2.10]**	1.08 [.76-1.53]
Emotional abuse	1.70 [1.23-2.35]**	1.16 [.79-1.71]	1.08 [.83-1.40]	1.04 [.80-1.33]	1.31 [.99-1.71]	1.25 [.87-1.81]	.86 [.62-1.18]	1.38 [1.00-1.91]*
Child separation	.65 [.42-1.02]	1.10 [.62-1.94]	.97 [.68-1.37]	1.06 [.76-1.48]	1.25 [.88-1.79]	1.14 [.69-1.87]	1.25 [.84-1.85]	1.09 [.68-1.74]
Parental divorce	.86 [.63-1.17]	.91 [.62-1.35]	1.15 [.88-1.51]	1.21 [.94-1.55]	.98 [.73-1.30]	1.08 [.76-1.52]	1.43 [1.04-1.97]*	.73 [.53-1.01]
Parental death	1.02 [.67-1.55]	.94 [.47-1.54]	1.25 [.94-1.66]	.89 [.66-1.20]	.94 [.66-1.34]	1.29 [.88-1.89]	.87 [.60-1.27]	1.26 [.86-1.87]
Exposure to violence	1.47 [.99-2.18]	.99 [.59-1.67]	.90 [.65-1.24]	.98 [.73-1.33]	1.47 [1.00-2.17]*	.80 [.51-1.27]	.81 [.58-1.13]	1.64 [1.04-2.58]*
Exposure to IPV	1.05 [.74-1.50]	1.23 [.81-1.86]	1.19 [.89-1.58]	.95 [.72-1.33]	1.52 [1.10-2.10]*	1.19 [.79-1.78]	.77 [.54-1.10]	2.48 [1.70-3.61]***
Household substance abuse	1.29 [.93-1.79]	1.19 [.81-1.86]	1.04 [.81-1.33]	1.07 [.84-1.35]	.81 [.59-1.10]	.88 [.61-1.25]	1.10 [.81-1.49]	.77 [.54-1.09]
Chronic unemployment	.85 [.54-1.34]	1.38 [.72-2.67]	1.29 [.83-1.99]	1.22 [.85-1.76]	.77 [.50-1.19]	.73 [.41-1.29]	1.79 [1.06-3.01]*	.70 [.43-1.13]
Household legal trouble	1.22 [.87-1.71]	1.53 [.99-2.36]	1.27 [.95-1.68]	1.01 [.79-1.29]	1.23 [.89-1.70]	.95 [.64-1.43]	.71 [.49-1.02]	1.56 [1.08-2.26]*
Household illness/disability	1.06 [.76-1.48]	.75 [.50-1.14]	1.20 [.91-1.58]	1.01 [.77-1.32]	.86 [.63-1.17]	1.13 [.77-1.65]	1.26 [.88-1.82]	1.13 [.79-1.63]
Household death	1.15 [.83-1.60]	.87 [.59-1.27]	.79 [.60-1.04]	1.43 [1.09-1.88]**	1.32 [.95-1.83]	1.10 [.76-1.58]	.90 [.62-1.32]	1.14 [.82-1.58]
Cumulative ACEs								
Less than 6	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
6 or more	1.61 [1.20-2.16]**	1.19 [.83-1.72]	1.67 [1.31-2.12]***	1.40 [1.10-1.77]**	1.39 [1.03-1.89]*	1.36 [.97-1.89]	1.12 [.86-1.45]	1.79 [1.32-2.42]***
0	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
1	.46 [.10-2.13]	N/A	1.61 [.15-16.87]	1.28 [.20-8.20]	1.41 [.13-15.75]	N/A	1.29 [.11-15.61]	.48 [.03-8.26]
2	.74 [.27-1.90]	.23 [.01-4.20]	2.11 [.22-19.75]	1.74 [.30-9.99]	2.26 [.24-21.44]	.79 [.12-4.69]	1.57 [.15-16.09]	1.12 [.11-11.25]
3	.42 [.19-.91]*	.93 [.10-8.40]	2.12 [.25-18.34]	1.98 [.38-10.34]	1.57 [.18-14.05]	.40 [.07-2.31]	1.71 [.19-15.75]	.88 [.10-7.81]
4+	N/A	.83 [.10-6.83]	3.52 [.43-28.72]	2.35 [.47-11.67]	2.39 [.28-20.05]	.51 [.10-2.53]	2.09 [.24-17.83]	1.43 [.17-11.71]
Clustered ACEs								
Class 1	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Class 2	1.41 [.68-2.94]	1.15 [.50-2.65]	1.83 [1.03-3.24]*	1.45 .88-2.38]	.94 [.56-1.58]	1.05 [.49-2.25]	1.65 [.90-3.02]	1.16 [.52-2.57]
Class 3	1.94 [.88-4.24]	1.64 [.68-4.01]	1.83 [1.02-3.27]*	1.29 [.76-2.19]	1.60 [.89-2.86]	1.27 [.56-2.84]	1.11 [.55-2.23]	2.59 [1.19-5.65]*
Class 4	2.23 [1.13-4.38]*	1.55 [.69-3.45]	2.97 [1.70-5.18]***	1.90 [1.16-3.13]*	1.66 [.95-2.92]	1.37 [.66-2.86]	1.61 [.84-3.07]	2.77 [1.29-5.95]**

***p*<.05 ****p*<.01 *****p*<.001**

N/A = omitted due to within cell sizes

The table shows the fold-increase in the odds (OR, odds ratio) of each adult human capital outcome (columns) for each level of ACEs measurement (rows). Models were run separately for each of the 3 ACE measurements

Table 5C: Crude associations between single, cumulative and clustered retrospective ACEs and health and human capital outcomes

	Psychological distress	Social isolation	Incomplete schooling	Unemployed	Substance use	HIV infection	Welfare receipt	Criminality
Single ACEs								
Physical abuse	1.06 [.63-1.80]	2.12 [1.06-4.22]*	1.10 [.64-1.88]	.98 [.62-1.57]	1.93 [1.11-3.35]*	.97 [.50-1.88]	.60 [.31-1.15]	1.58 [.87-2.86]
Sexual abuse	2.30 [1.21-4.39]*	1.58 [.68-3.69]	1.05 [.51-2.17]	.89 [.45-1.78]	1.25 [.60-2.60]	2.84 [1.04-7.75]*	1.50 [.65-3.47]	1.33 [.61-2.89]
Emotional abuse	1.90 [1.35-2.68]***	.83 [.68-3.69]	1.57 [1.19-2.08]**	1.09 [.84-1.41]	1.00 [.70-1.43]	1.32 [.82-2.11]	1.09 [.80-1.50]	1.32 [.95-1.84]
Parental divorce	.79 [.58-1.08]	.63 [.41-.96]*	.83 [.64-1.06]	1.06 [.78-1.45]	.92 [.66-1.30]	.87 [.52-1.47]	1.17 [.80-1.71]	.91 [.62-1.32]
Parental death	1.09 [.75-1.57]	1.37 [.85-2.22]	1.28 [.95-1.74]	.96 [.70-1.30]	.81 [.56-1.18]	1.11 [.76-1.61]	.78 [.53-1.15]	1.39 [.96-1.99]
Exposure to violence	.93 [.64-1.34]	1.41 [.90-2.21]	.99 [.75-1.32]	.96 [.72-1.27]	1.97 [1.47-2.64]***	.90 [.57-1.42]	.75 [.54-1.02]	1.71 [1.15-2.52]**
Exposure to IPV	.99 [.62-1.56]	.54 [.27-1.08]	.83 [.56-1.21]	.65 [.44-.97]*	1.02 [.64-1.64]	.69 [.38-1.24]	.88 [.56-1.38]	1.14 [.71-1.81]
Household substance abuse	1.30 [.92-1.83]	1.81 [1.18-2.76]**	1.22 [.87-1.72]	1.73 [1.33-2.25]***	1.14 [.81-1.59]	1.63 [1.12-2.38]*	.91 [.62-1.34]	1.15 [.80-1.65]
Chronic unemployment	1.10 [.79-1.53]	1.36 [.91-2.05]	1.21 [.91-1.59]	1.31 [1.03-1.66]*	.98 [.74-1.29]	.81 [.54-1.20]	1.31 [.99-1.74]	1.29 [.94-1.76]
Household legal trouble	.91 [.62-1.33]	.73 [.44-1.20]	1.00 [.74-1.36]	.96 [.68-1.35]	1.20 [.81-1.78]	1.22 [.80-1.86]	.90 [.61-1.34]	1.13 [.79-1.63]
Household illness/disability	1.75 [1.23-2.48]**	.79 [.51-1.22]	.91 [.68-1.21]	.76 [.58-.98]*	.72 [.54-.96]	.73 [.49-1.09]	1.08 [.77-1.51]	.85 [.54-1.34]
Household death	.95 [.67-1.33]	1.04 [.70-1.56]	.89 [.67-1.18]	1.16 [.87-1.53]	1.00 [.74-1.36]	.79 [.50-1.25]	.97 [.60-1.55]	.75 [.50-1.12]
Cumulative ACEs								
Less than 6	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
6 or more	1.57 [1.11-2.32]*	.98 [.53-1.80]	1.55 [1.09-2.19]*	1.33 [.95-1.86]	1.29 [.88-1.88]	.94 [.54-1.63]	.80 [.46-1.40]	1.91 [1.28-2.83]**
0	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
1	1.89 [.83-4.33]	1.07 [.49-2.32]	.99 [.61-1.62]	1.43 [.87-2.34]	.97 [.57-1.65]	1.09 [.51-2.33]	1.16 [.64-2.09]	1.50 [.70-3.19]
2	1.87 [.83-4.19]	1.01 [.46-2.25]	1.38 [.85-2.24]	1.23 [.77-1.98]	.98 [.57-1.68]	1.30 [.64-2.62]	1.58 [.88-2.85]	1.38 [.62-3.05]
3	2.81 [1.25-6.35]*	1.56 [.73-3.30]	1.28 [.80-2.08]	1.21 [.75-1.97]	1.54 [.90-2.61]	.97 [.45-2.12]	1.30 [.72-2.33]	2.55 [1.19-5.46]*
4+	3.75 [1.74-8.08]**	1.26 [.63-2.54]	1.47 [.94-2.31]	1.46 [.92-2.30]	1.36 [.86-2.17]	1.25 [.63-2.50]	1.18 [.62-2.25]	2.50 [1.20-5.14]*
Clustered ACEs								
Class 1	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Class 2	1.48 [.99-2.21]	1.26 [.80-2.00]	1.26 [.93-1.71]	1.30 [.99-1.72]	1.05 [.76-1.45]	.75 [.47-1.17]	1.47 [1.06-2.05]*	1.45 [.99-2.17]
Class 3	2.58 [1.67-3.99]***	1.04 [.59-1.83]	1.18 [.83-1.68]	.91 [.64-1.28]	1.24 [.84-1.82]	1.12 [.69-1.81]	1.05 [.66-1.68]	1.61 [1.03-2.53]*
Class 4	2.56 [1.64-4.00]***	1.25 [.71-2.20]	1.56 [1.09-2.24]*	1.28 [.89-1.83]	1.18 [.79-1.73]	1.14 [.71-1.84]	1.06 [.64-1.73]	2.10 [1.35-3.27]**

***$p<.05$ **$p<.01$ ***$p<.001$**

N/A = omitted due to within cell sizes

The table shows the fold-increase in the odds (OR, odds ratio) of each adult human capital outcome (columns) for each level of ACEs measurement (rows). Models were run separately for each of the 3 ACE measurements

Table 5D: Adjusted associations between single, cumulative and clustered prospective ACEs and health and human capital outcomes

	Psychological distress	Social isolation	Incomplete schooling	Unemployed	Substance use	HIV infection	Welfare receipt	Criminality
Single ACEs								
Physical abuse	1.20 [.85-1.69]	1.12 [.75-1.68]	1.69 [1.21-2.35]**	1.31 [1.02-1.69]*	1.04 [.74-1.47]	1.30 [.85-1.99]	1.33 [.90-1.99]	.86 [.528-1.29]
Sexual abuse	.95 [.65-1.37]	.64 [.42-.99]*	1.58 [1.21-2.08]**	1.20 [.92-1.57]	.87 [.62-1.22]	1.31 [.90-1.91]	1.53 [1.07-2.20]*	1.11 [.77-1.61]
Emotional abuse	1.74 [1.24-2.44]**	1.19 [.80-1.76]	1.09 [.81-1.45]	1.06 [.81-1.38]	1.37 [1.02-1.84]*	1.28 [.86-1.90]	.85 [.58-1.25]	1.36 [.95-1.93]
Child separation	.57 [.36-.91]*	1.17 [.65-2.09]	1.03 [.70-1.51]	1.05 [.74-1.49]	1.35 [.92-1.97]	1.08 [.64-1.82]	1.09 [.69-1.72]	1.21 [.72-2.01]
Parental divorce	.81 [.58-1.13]	.96 [.64-1.45]	1.22 [.90-1.65]	1.19 [.91-1.56]	1.06 [.78-1.44]	1.04 [.72-1.51]	1.31 [.89-1.92]	.78 [.55-1.12]
Parental death	1.02 [.66-1.58]	.91 [.54-1.52]	1.10 [.81-1.49]	.81 [.59-1.11]	.95 [.64-1.40]	1.26 [.82-1.93]	.87 [.57-1.32]	1.25 [.83-1.90]
Exposure to violence	1.64 [1.08-2.49]*	.95 [.56-1.62]	.87 [.61-1.25]	1.00 [.73-1.37]	1.33 [.88-2.00]	.84 [.52-1.34]	.96 [.65-1.41]	1.45 [.88-2.39]
Exposure to IPV	1.18 [.83-1.69]	1.11 [.73-1.69]	1.03 [.76-1.40]	.86 [.64-1.16]	1.39 [.95-2.02]	1.20 [.78-1.84]	.85 [.54-1.34]	2.27 [1.49-3.45]***
Household substance abuse	1.23 [.88-1.73]	1.20 [.81-1.79]	.99 [.76-1.30]	1.04 [.81-1.34]	.84 [.60-1.17]	.83 [.56-1.22]	1.01 [.70-1.46]	.84 [.59-1.21]
Chronic unemployment	.82 [.50-1.32]	1.34 [.67-2.68]	1.23 [.76-1.98]	1.10 [.75-1.63]	.83 [.52-1.34]	.69 [.38-1.27]	1.71 [.97-3.04]	.71 [.42-1.20]
Household legal trouble	1.34 [.95-1.88]	1.46 [.93-2.30]	1.17 [.87-1.59]	.95 [.74-1.23]	1.06 [.75-1.51]	1.00 [.66-1.54]	.81 [.51-1.29]	1.36 [.93-2.00]
Household illness/disability	1.04 [.74-1.47]	.71 [.47-1.06]	1.27 [.95-1.72]	1.07 [.81-1.42]	.84 [.61-1.16]	1.18 [.78-1.78]	1.33 [.83-2.14]	1.21 [.83-1.78]
Household death	1.12 [.80-1.58]	.88 [.59-1.30]	.80 [.59-1.07]	1.57 [1.17-2.11]**	1.35 [.95-1.90]	1.13 [.77-1.66]	.89 [.56-1.41]	1.15 [.82-1.61]
		.						
Cumulative ACEs								
Less than 6	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
6 or more	1.63 [1.19-2.23]**	1.08 [.75-1.57]	1.51 [1.15-1.99]**	1.28 [1.10-1.64]*	1.39 [.98-1.99]	1.36 [.95-1.95]	1.18 [.87-1.61]	1.80 [1.28-2.54]**
0	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
1	.47 [.09-2.43]	N/A	1.29 [.11-15.03]	1.11 [.16-7.59]	1.46 [.11-19.53]	N/A	1.49 [.09-23.76]	.34 [.02-6.37]
2	.68 [.25-1.84]	N/A	1.49 [.15-15.03]	1.28 [.21-7.64]	3.16 [.29-34.36]	N/A	1.25 [.10-16.01]	1.31 [.11-15.13]
3	.40 [.18-.88]*	1.42 [.55-3.67]	1.38 [.15-12.88]	1.48 [.27-8.21]	1.87 [.18-18.97]	.71 [.22-2.25]	1.67 [.14-19.55]	.74 [.07-7.38]
4+	N/A	N/A	2.31 [.26-20.57]	1.72 [.33-8.98]	2.71 [.29-25.48]	N/A	2.19 [.21-23.13]	1.22 [.14-10.88]
Clustered ACEs								
Class 1	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Class 2	1.40 [.65-3.00]	1.08 [.46-2.55]	1.77 [.97-3.20]	1.33 [.79-2.24]	.98 [.56-1.72]	1.01 [.46-2.19]	1.67 [.87-3.18]	1.21 [.52-2.84]
Class 3	2.23 [1.10-5.04]*	1.41 [.55-3.52]	1.51 [.81-2.81]	1.08 [.62-1.86]	1.46 [.78-2.73]	1.24 [.54-2.89]	1.36 [.63-2.91]	2.29 [1.01-5.22]*
Class 4	2.47 [1.19-5.09]*	1.25 [.55-2.86]	2.39 [1.33-4.31]**	1.56 [.93-2.67]	1.58 [.84-2.98]	1.33 [.62-2.86]	1.96 [.97-3.93]	2.60 [1.12-6.02]*

***p*<.05 ****p*<.01 *****p*<.001**

N/A = omitted due to within cell sizes

The table shows the fold-increase in the odds (OR, odds ratio) of each adult human capital outcome (columns) for each level of ACEs measurement (rows). Models were run separately for each of the 3 ACE measurements and fully adjusted for all covariates, including sex, SES at birth, SES at age 12, SES at age 22, maternal age at birth and maternal and paternal schooling.

Table 5E: Adjusted associations between single, cumulative and clustered retrospective ACEs and health and human capital outcomes

	Psychological distress	Social isolation	Incomplete schooling	Unemployed	Substance use	HIV infection	Welfare receipt	Criminality
Single ACEs								
Physical abuse	1.32 [.76-2.28]	1.92 [.93-3.98]	1.16 [.66-2.04]	1.02 [.63-1.64]	1.62 [.89-2.96]	1.03 [.51-2.08]	.79 [.38-1.67]	1.37 [.72-2.59]
Sexual abuse	2.05 [1.02-4.12]*	1.83 [.75-4.50]	1.15 [.53-2.48]	.80 [.39-1.66]	1.50 [.66-3.40]	3.03 [1.03-7.91]*	1.09 [.43-2.72]	1.90 [.80-4.50]
Emotional abuse	1.96 [1.37-2.82]***	.82 [.53-1.27]	1.48 [1.09-2.01]*	1.04 [.79-1.36]	1.02 [.71-1.48]	1.30 [.80-2.11]	1.10 [.77-1.57]	1.35 [.94-1.92]
Parental divorce	.82 [.59-1.13]	.64 [.41-.99]*	.81 [.61-1.07]	1.04 [.75-1.46]	.96 [.66-1.40]	.85 [.47-1.51]	1.12 [.71-1.78]	.95 [.63-1.43]
Parental death	1.17 [.80-1.72]	1.39 [.85-2.26]	1.17 [.84-1.62]	.89 [.64-1.22]	.79 [.53-1.17]	1.09 [.73-1.64]	.79 [.50-1.22]	1.30 [.88-1.92]
Exposure to violence	1.05 [.71-1.55]	1.27 [.80-2.01]	.97 [.72-1.30]	.95 [.71-1.26]	1.73 [1.28-2.35]***	.97 [.60-1.55]	.92 [.64-1.33]	1.47 [.97-2.22]
Exposure to IPV	.95 [.60-1.53]	.57 [.28-1.13]	.92 [.61-1.37]	.69 [.45-1.04]	1.05 [.64-1.72]	.72 [.39-1.32]	.81 [.49-1.34]	1.32 [.80-2.18]
Household substance abuse	1.39 [.96-2.02]	1.61 [1.04-2.50]*	1.03 [.72-1.48]	1.56 [1.19-2.06]**	1.16 [.81-1.65]	1.50 [1.00-2.24]*	.92 [.59-1.43]	1.07 [.74-1.57]
Chronic unemployment	1.14 [.81-1.61]	1.26 [.81-1.97]	.92 [.67-1.25]	1.10 [.85-1.42]	.99 [.73-1.34]	.68 [.42-1.09]	1.27 [.92-1.76]	1.29 [.90-1.87]
Household legal trouble	.88 [.60-1.31]	.71 [.42-1.21]	.94 [.68-1.29]	.92 [.65-1.31]	1.12 [.75-1.69]	1.19 [.75-1.87]	.98 [.62-1.53]	1.06 [.73-1.55]
Household illness/disability	1.71[1.16-2.48]**	.86 [.55-1.36]	.93 [.68-1.27]	.76 [.58-.99]*	.77 [.57-1.06]	.70 [.45-1.09]	.99 [.67-1.46]	.87 [.52-1.44]
Household death	.91 [.64-1.30]	1.04 [.565-1.36]	.87 [.63-1.19]	1.20 [.90-1.60]	.97 [.70-1.34]	.79 [.49-1.26]	.95 [.55-1.65]	.71 [.46-1.08]
Cumulative ACEs								
Less than 6	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
6 or more	1.72 [1.13-2.61]*	.88 [.46-1.69]	1.21 [.83-1.76]	1.12 [.78-1.59]	1.22 [.82-1.82]	.84 [.47-1.49]	.83 [.44-1.57]	1.69 [1.09-2.63]*
0	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
1	1.88 [.82-4.30]	1.06 [.47-2.39]	.76 [.45-1.28]	1.29 [.76-2.00]	.92 [.53-1.59]	.97 [.44-2.13]	1.14 [.58-2.22]	1.55 [.69-3.48]
2	1.71 [.76-3.84]	1.08 [.47-2.49]	1.14 [.68-1.91]	1.07 [.65-1.77]	1.07 [.61-1.88]	1.12 [.54-2.30]	1.35 [.70-2.60]	1.60 [.69-3.70]
3	2.87 [1.26-6.54]**	1.49 [.67-3.29]	.93 [.56-1.55]	1.01 [.60-1.68]	1.48 [.84-2.61]	.79 [.35-1.80]	1.27 [.65-2.51]	2.54 [1.13-5.72]*
4+	4.08 [1.88-6.85]***	1.15 [.54-2.44]	.93 [.57-1.51]	1.09 [.67-1.78]	1.31 [.80-2.16]	1.02 [.49-2.10]	1.17 [.55-2.46]	2.43 [1.08-5.46]*
Clustered ACEs								
Class 1	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Class 2	1.52 [1.01-2.29]*	1.18 [.73-1.92]	.95 [.68-1.32]	1.05 [.78-1.40]	1.08 [.76-1.53]	.62 [.37-1.03]	1.41 [.98-2.05]	1.51 [.97-2.37]
Class 3	2.82 [1.8 -4.41] ***	1.01 [.57-1.81]	1.05 [.72-1.52]	.80 [.57-1.14]	1.27 [.84-1.93]	1.07 [.65-1.77]	1.01 [.60-1.70]	1.69 [1.04-2.73]*
Class 4	2.97 [1.86-4.74]***	1.09 [.58-2.04]	.98 [.66-1.46]	.94 [.63-1.39]	1.15 [.74-1.78]	.88 [.50-1.53]	1.08 [.61-1.92]	2.01 [1.18-3.29]**

***$p<.05$ **$p<.01$ ***$p<.001$**

N/A = omitted due to within cell sizes

The table shows the fold-increase in the odds (OR, odds ratio) of each adult human capital outcome (columns) for each level of ACEs measurement (rows). Models were run separately for each of the 3 ACE measurements and fully adjusted for all covariates, including sex, SES at birth, SES at age 12, SES at age 22, maternal age at birth and maternal and paternal schooling.

Table 5F: Adjusted associations between single, cumulative and clustered prospective ACEs and health and human capital outcomes, by sex

	Psychological distress		Social isolation		Incomplete schooling		Unemployed		Substance use		HIV infection		Welfare receipt		Criminality	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Single ACEs																
Physical abuse	1.16 [0.64-2.12]	1.29 [0.86-1.95]	0.8 [0.48-1.35]	1.8 [0.88-3.66]	1.46 [0.96-2.21]	2.08*** [1.25-3.45]	1.28 [0.87-1.89]	1.37 [0.95-1.97]	1.03 [0.66-1.6]	1.05 [0.6-1.83]	1.47 [0.77-2.82]	1.22 [0.71-2.09]	1.3 [0.6-2.82]	1.36 [0.92-2.02]	0.89 [0.57-1.38]	0.79 [0.35-1.78]
Sexual abuse	0.93 [0.47-1.82]	0.96 [0.62-1.48]	0.75 [0.44-1.29]	0.53 [0.25-1.09]	1.68*** [1.17-2.4]	1.52* [1.01-2.31]	1.41 [0.95-2.09]	1.08 [0.72-1.6]	0.75 [0.51-1.1]	1.07 [0.59-1.93]	1.49 [0.76-2.95]	1.2 [0.72-2.00]	1.51 [0.74-3.11]	1.56* [1.06-2.3]	0.97 [0.62-1.5]	1.86 [0.91-3.79]
Emotional abuse	2.54** [1.42-4.53]	1.44 [0.93-2.22]	1.03 [0.59-1.81]	1.47 [0.7-3.09]	1.12 [0.75-1.66]	1.05 [0.65-1.71]	1.04 [0.7-1.55]	1.06 [0.74-1.52]	1.52* [1.03-2.25]	1.20 [0.71-2.05]	1.70 [0.96-2.99]	1.08 [0.65-1.8]	0.66 [0.28-1.56]	0.94 [0.63-1.41]	1.57* [1.04-2.38]	0.94 [0.39-2.22]
Child separation	0.51 [0.21-1.24]	0.6 [0.34-1.06]	1.46 [0.68-3.15]	0.81 [0.29-2.29]	0.88 [0.49-1.6]	1.2 [0.69-2.06]	1.06 [0.6-1.86]	1.04 [0.64-1.69]	1.13 [0.64-1.97]	1.6 [0.93-2.74]	0.72 [0.27-1.93]	1.25 [0.68-2.31]	1.26 [0.48-3.28]	1.02 [0.63-1.66]	1.29 [0.74-2.24]	1.21 [0.45-3.24]
Parental divorce	0.72 [0.36-1.41]	0.82 [0.53-1.24]	0.83 [0.48-1.42]	1.03 [0.54-1.95]	1.28 [0.82-2.02]	1.13 [0.75-1.71]	1.15 [0.79-1.68]	1.23 [0.85-1.78]	0.93 [0.65-1.35]	1.30 [0.75-2.23]	0.79 [0.41-1.54]	1.28 [0.81-2.03]	1.44 [0.7-2.93]	1.29 [0.84-1.97]	0.74 [0.48-1.12]	1.03 [0.46-2.32]
Parental death	0.86 [0.39-1.89]	1.14 [0.69-1.88]	0.73 [0.36-1.5]	1.43 [0.66-3.07]	0.85 [0.55-1.31]	1.63 [0.97-2.72]	0.82 [0.52-1.28]	0.79 [0.51-1.22]	0.92 [0.57-1.47]	1.01 [0.53-1.95]	1.4 [0.75-2.65]	1.09 [0.57-2.09]	0.71 [0.24-2.14]	0.96 [0.62-1.5]	1.06 [0.64-1.76]	1.92 [0.77-4.79]
Exposure to violence	3.05* [1.01-9.18]	1.52 [0.97-2.39]	1.34 [0.62-2.89]	0.68 [0.33-1.41]	0.94 [0.54-1.64]	0.81 [0.52-1.27]	1.03 [0.58-1.81]	1.01 [0.69-1.49]	1.57 [0.9-2.77]	1.04 [0.62-1.77]	0.88 [0.36-2.2]	0.80 [0.46-1.41]	0.69 [0.25-1.87]	1.05 [0.69-1.61]	1.60 [0.85-3.02]	1.46 [0.62-3.46]
Exposure to IPV	1.18 [0.57-2.44]	1.05 [0.68-1.64]	0.83 [0.47-1.49]	1.6 [0.77-3.3]	1.18 [0.79-1.79]	0.81 [0.51-1.3]	0.79 [0.53-1.18]	0.95 [0.64-1.42]	1.42 [0.89-2.25]	1.26 [0.64-2.49]	0.92 [0.47-1.83]	1.43 [0.86-2.37]	0.94 [0.37-2.4]	0.86 [0.51-1.45]	2.16** [1.31-3.55]	2.02 [0.81-5.06]
Household substance abuse	1.28 [0.68-2.42]	1.21 [0.81-1.82]	1.71 [0.97-3.02]	0.78 [0.41-1.5]	1.00 [0.68-1.47]	1.01 [0.65-1.58]	1.12 [0.77-1.64]	0.99 [0.67-1.45]	0.79 [0.5-1.26]	0.88 [0.54-1.43]	0.62 [0.31-1.25]	1.00 [0.61-1.63]	0.89 [0.38-2.12]	1.05 [0.72-1.54]	0.85 [0.55-1.32]	0.83 [0.38-1.79]
Chronic unemployment	0.52 [0.21-1.26]	0.98 [0.54-1.77]	0.88 [0.36-2.13]	2.37 [0.7-8.07]	0.89 [0.46-1.7]	1.87 [0.81-4.32]	0.78 [0.41-1.49]	1.49 [0.89-2.52]	1.01 [0.55-1.86]	0.6 [0.29-1.25]	0.75 [0.3-1.91]	0.56 [0.27-1.16]	1.26 [0.39-4.02]	2.03* [1.07-3.86]	0.77 [0.38-1.59]	0.6 [0.22-1.61]
Household legal trouble	1.72 [0.91-3.26]	1.15 [0.74-1.78]	1.63 [0.94-2.83]	1.39 [0.65-2.97]	1.46 [0.96-2.21]	0.91 [0.56-1.47]	0.97 [0.67-1.41]	0.94 [0.65-1.37]	1.15 [0.77-1.72]	0.94 [0.53-1.66]	1.03 [0.56-1.91]	1.03 [0.58-1.82]	0.79 [0.27-2.28]	0.81 [0.54-1.23]	1.46 [0.97-2.2]	1.21 [0.53-2.76]
Household illness/disability	1.46 [0.77-2.77]	0.89 [0.57-1.4]	0.91 [0.53-1.58]	0.56 [0.27-1.15]	1.68 [1.17-2.4]	1.33 [0.85-2.07]	1.34 [0.91-1.96]	0.87 [0.57-1.34]	0.72 [0.48-1.08]	1.11 [0.61-2.04]	1.49 [0.79-2.8]	1.02 [0.59-1.76]	1.62 [0.68-3.87]	1.24 [0.76-2.05]	1.26 [0.81-1.94]	0.99 [0.47-2.12]
Household death	1.3 [0.68-2.46]	0.97 [0.64-1.47]	0.93 [0.56-1.56]	0.79 [0.41-1.51]	1.12 [0.75-1.66]	0.67 [0.42-1.06]	1.55* [1.03-2.33]	1.65* [1.09-2.5]	1.31 [0.85-2.03]	1.39 [0.8-2.4]	1.14 [0.62-2.09]	1.13 [0.67-1.89]	0.96 [0.42-2.22]	0.87 [0.56-1.36]	1.27 [0.82-1.96]	0.95 [0.39-2.34]
Cumulative ACEs																
Less than 6	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
6 or more	1.97* [1.11-3.48]	1.44 [0.98-2.11]	1.26 [0.76-2.07]	0.88 [0.46-1.67]	1.74** [1.2-2.53]	1.24 [0.8-1.91]	1.47* [1.04-2.09]	1.16 [0.8-1.69]	1.34 [0.91-1.98]	1.47 [0.79-2.71]	1.43 [0.82-2.48]	1.37 [0.81-2.32]	0.94 [0.39-2.24]	1.29 [0.92-1.82]	1.84** [1.22-2.76]	1.8 [0.93-3.49]
0	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
1	N/A	0.65 [0.11-3.83]	N/A	N/A	0.39 [0.02-7.99]	0.59 [0.08-4.4]	0.11 [0.01-2.41]	0.8 [0.2-3.26]	1.03 [0.06-19.19]	N/A	N/A	N/A	N/A	1.3 [0.08-22.15]	0.21 [0.01-5.1]	N/A
2	N/A	0.88 [0.3-2.58]	N/A	N/A	0.66 [0.04-11.22]	0.57 [0.15-2.19]	0.34 [0.02-6.4]	0.51 [0.18-1.49]	2.02 [0.12-33.19]	N/A	N/A	N/A	N/A	1.06 [0.07-15.6]	0.87 [0.06-13.82]	N/A
3	N/A	0.47 [0.18-1.18]	N/A	N/A	0.39 [0.03-5.37]	0.75 [0.32-1.74]	0.15 [0.01-2.22]	1.04 [0.57-1.93]	1.17 [0.09-16.16]	0.54 [0.06-4.5]	0.82 [0.13-4.97]	0.65 [.13-3.33]	N/A	1.48 [0.12-17.87]	0.36 [0.03-4.89]	1.09 [0.16-7.48]
4+	N/A	N/A	N/A	N/A	0.77 [0.06-9.67]	N/A	0.21 [0.02-2.89]	N/A	1.77 [0.14-21.9]	N/A	N/A	N/A	N/A	2.06 [0.17-24.36]	0.67 [0.06-7.9]	N/A
LCA derived clusters																
Class 2	0.29 [0.08-1.05]	1.14 [0.52-2.47]	1.24 [0.34-4.46]	0.9 [0.27-3.04]	1.77 [0.67-4.65]	1.67 [0.76-3.69]	0.92 [0.39-2.16]	1.74 [0.91-3.36]	0.86 [0.39-1.89]	1.16 [0.48-2.82]	1.42 [0.37-5.41]	0.79 [0.32-1.96]	N/A	1.61 [0.85-3.02]	1.25 [0.47-3.32]	1.37 [0.31-6.04]
Class 3	0.74 [0.24-2.31]	1.53 [0.59-4]	1.16 [0.3-4.42]	1.77 [0.49-6.33]	1.67 [0.61-4.59]	1.25 [0.48-3.26]	0.62 [0.26-1.5]	1.74 [0.82-3.7]	1.58 [0.72-3.46]	1.23 [0.42-3.55]	1.13 [0.25-5.12]	1.34 [0.52-3.48]	N/A	1.4 [0.68-2.89]	2.07 [0.77-5.57]	2.98 [0.67-13.24]
Class 4	N/A	1.64 [0.74-3.65]	1.57 [0.45-5.46]	0.81 [0.24-2.76]	2.5 [0.98-6.42]	2.09 [0.87-5.02]	1.19 [0.51-2.8]	1.9 [0.97-3.74]	1.56 [0.74-3.31]	1.62 [0.58-4.52]	1.59 [0.41-6.12]	1.12 [0.45-2.78]	N/A	2.11* [1.1-4.05]	2.84 [1.1-7.34]*	2.21 [0.44-11.12]

*p<.05 **p<.01 ***p<.001; N/A = omitted due to within cell sizes. The table shows the fold-increase in the odds (OR, odds ratio) of each adult human capital outcome (columns) for each level of ACEs measurement (rows). Models were run separately for each of the 3 ACE measurements and fully adjusted for all covariates, including sex, SES at birth, SES at age 12, SES at age 22, maternal age at birth and maternal and paternal schooling.

Table 5G: Adjusted associations between single, cumulative and clustered retrospective ACEs and health and human capital outcomes, by sex

	Psychological distress		Social isolation		Incomplete schooling		Unemployed		Substance use		HIV infection		Welfare receipt		Criminality	
	Male	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**
Single ACEs																
Physical abuse	1.39 [0.6-3.22]	1.19 [0.53-2.69]	0.96 [0.33-2.74]	6.02** [1.93-8.85]	0.91 [0.45-1.85]	1.73 [0.66-4.52]	0.98 [0.51-1.87]	1.27 [0.56-2.85]	1.74 [0.85-3.56]	1.4 [0.32-6.09]	1.26 [0.49-3.26]	0.80 [0.26-2.44]	0.65 [0.12-3.4]	0.94 [0.42-2.11]	1.44 [0.71-2.91]	1.07 [0.21-5.49]
Sexual abuse	1.61 [0.35-7.39]	2.20 [0.97-5.01]	1.97 [0.43-8.98]	1.59 [0.42-5.97]	1.6 [0.49-5.24]	0.91 [0.29-2.79]	0.66 [0.2-2.21]	0.9 [0.36-2.24]	1.24 [0.38-4.09]	1.69 [0.59-4.82]	2.8 [0.27-29.35]	3.32* [1.01-10.91]	1.48 [0.18-12]	0.93 [0.37-2.37]	1.82 [0.56-5.93]	3.25 [0.9-11.76]
Emotional abuse	1.88 [0.93-3.79]	2.15** [1.39-3.32]	0.74 [0.4-1.36]	0.93 [0.44-1.96]	1.47 [0.94-2.3]	1.6* [1.02-2.49]	1.17 [0.8-1.73]	0.93 [0.62-1.39]	1.23 [0.77-1.95]	0.78 [0.44-1.39]	1.33 [0.67-2.68]	1.21 [0.68-2.15]	1.13 [0.59-2.16]	1.09 [0.71-1.67]	1.38 [0.91-2.1]	1.46 [0.66-3.24]
Parental divorce	0.83 [0.47-1.49]	0.79 [0.52-1.21]	0.52* [0.28-1]	0.78 [0.38-1.6]	0.88 [0.57-1.36]	0.7 [0.45-1.1]	0.9 [0.6-1.35]	1.21 [0.76-1.92]	0.86 [0.54-1.36]	1.10 [0.63-1.93]	0.84 [0.4-1.77]	0.87 [0.47-1.62]	1.02 [0.42-2.49]	1.18 [0.77-1.81]	0.84 [0.52-1.36]	1.49 [0.6-3.68]
Parental death	0.97 [0.5-1.88]	1.36 [0.84-2.20]	1.26 [0.68-2.31]	1.54 [0.68-3.46]	1.1 [0.7-1.74]	1.26 [0.79-1.99]	1.05 [0.69-1.59]	0.7 [0.45-1.11]	0.69 [0.45-1.06]	0.93 [0.45-1.94]	1.21 [0.67-2.21]	1.02 [0.59-1.77]	0.82 [0.32-2.09]	0.78 [0.49-1.25]	1.03 [0.66-1.62]	2.21 [0.93-5.26]
Exposure to violence	0.92 [0.49-1.72]	1.17 [0.72-1.92]	1.15 [0.64-2.06]	1.51 [0.71-3.2]	0.92 [0.62-1.38]	1.02 [0.62-1.69]	0.94 [0.63-1.42]	1.00 [0.67-1.49]	1.96** [1.3-2.96]	1.52 [0.85-2.75]	0.90 [0.44-1.83]	1.04 [0.57-1.89]	1.02 [0.45-2.33]	0.86 [0.54-1.37]	1.58 [0.99-2.53]	1.11 [0.42-2.95]
Exposure to IPV	0.91 [0.36-2.29]	1.10 [0.59-2.04]	0.74 [0.3-1.82]	0.24 [0.05-1.15]	1.03 [0.6-1.76]	0.78 [0.39-1.57]	0.97 [0.56-1.66]	0.46* [0.23-0.94]	0.87 [0.46-1.62]	1.48 [0.64-3.43]	0.77 [0.29-2.03]	0.69 [0.32-1.49]	0.95 [0.22-4.1]	0.72 [0.4-1.31]	1.44 [0.77-2.68]	1.01 [0.3-3.36]
Household substance abuse	2.08* [1.09-3.99]	1.01 [0.62-1.63]	1.56 [0.86-2.84]	1.87 [0.91-3.85]	1.17 [0.71-1.91]	0.9 [0.54-1.48]	1.8** [1.21-2.66]	1.38 [0.85-2.24]	1.31 [0.85-2.03]	0.82 [0.42-1.62]	1.37 [0.72-2.6]	1.68 [0.98-2.87]	0.96 [0.43-2.18]	0.9 [0.54-1.48]	1.25 [0.82-1.91]	0.72 [0.26-2.04]
Chronic unemployment	1 [0.56-1.79]	1.27 [0.83-1.95]	1.7 [0.96-3.02]	0.87 [0.42-1.78]	0.85 [0.55-1.31]	1.05 [0.68-1.61]	1.16 [0.75-1.77]	1.02 [0.71-1.47]	0.96 [0.64-1.43]	0.97 [0.58-1.64]	0.65 [0.31-1.34]	0.67 [0.37-1.2]	0.95 [0.42-2.13]	1.47* [1.02-2.11]	1.38 [0.9-2.11]	1.08 [0.47-2.47]
Household legal trouble	0.85 [0.42-1.7]	0.94 [0.57-1.56]	0.61 [0.3-1.24]	0.97 [0.39-2.41]	1.04 [0.68-1.59]	0.87 [0.52-1.46]	0.9 [0.57-1.42]	0.96 [0.57-1.6]	0.98 [0.61-1.57]	1.49 [0.77-2.86]	1.54 [0.82-2.88]	0.88 [0.44-1.76]	0.61 [0.28-1.33]	1.17 [0.63-2.16]	1.09 [0.71-1.68]	0.99 [0.41-2.41]
Household illness/disability	1.53 [0.77-3.04]	1.88** [1.18-2.98]	0.74 [0.4-1.37]	1.07 [0.53-2.19]	0.97 [0.64-1.48]	0.88 [0.54-1.43]	0.71 [0.46-1.1]	0.78 [0.54-1.11]	0.92 [0.59-1.45]	0.58 [0.34-1.00]	0.88 [0.47-1.66]	0.57* [0.33-0.99]	1.07 [0.47-2.45]	0.95 [0.63-1.44]	0.74 [0.44-1.25]	1.44 [0.58-3.55]
Household death	0.83 [0.44-1.55]	0.91 [0.59-1.42]	1.01 [0.57-1.78]	1.03 [0.54-1.99]	0.78 [0.47-1.3]	0.95 [0.61-1.48]	1.25 [0.84-1.88]	1.18 [0.8-1.75]	1.06 [0.72-1.54]	0.84 [0.47-1.53]	0.96 [0.43-2.14]	0.69 [0.39-1.21]	0.89 [0.29-2.76]	0.97 [0.61-1.53]	0.74 [0.45-1.22]	0.64 [0.27-1.49]
Cumulative ACEs																
Less than 6	**Ref**	**Ref**	**Ref**	**Ref**	**Ref**	**Ref**	**Ref**	**Ref**	**Ref**	**Ref**	**Ref**	**Ref**	**Ref**	**Ref**	**Ref**	**Ref**
6 ore more	**1.46 [0.76-2.82]**	**2.04 [1.17-3.58]**	**0.7 [0.29-1.7]**	**1.26 [0.51-3.08]**	**1.27 [0.79-2.03]**	**1.15 [0.62-2.14]**	**1.43 [0.84-2.42]**	**0.85 [0.5-1.45]**	**1.34 [0.8-2.24]**	**1.02 [0.48-2.18]**	**1.09 [0.48-2.46]**	**0.66 [0.3-1.46]**	**0.54 [0.16-1.86]**	**1.03 [0.54-1.98]**	**1.47 [0.87-2.48]**	**2.77* [1.18-6.5]**
0	**Ref**	**Ref**	**Ref**	**Ref**	**Ref**	**Ref**	**Ref**	**Ref**	**Ref**	**Ref**	**Ref**	**Ref**	**Ref**	**Ref**	**Ref**	**Ref**
1	**1.2 [0.3-4.88]**	**2.60 [0.93-7.31]**	**0.66 [0.25-1.77]**	**2.67 [0.44-16.12]**	**0.74 [0.35-1.57]**	**0.79 [0.35-1.74]**	**0.87 [0.39-1.91]**	**1.75 [0.91-3.39]**	**0.97 [0.45-2.09]**	**0.84 [0.35-2]**	**0.7 [0.2-2.47]**	**1.25 [0.44-3.53]**	**1.44 [0.32-6.52]**	**1.09 [0.51-2.34]**	**2.31 [0.8-6.73]**	**0.74 [0.2-2.74]**
2	1.39 [0.31-6.18]	2.06 [0.73-5.82]	0.91 [0.34-2.43]	1.85 [0.31-10.91]	1.04 [0.49-2.2]	1.27 [0.6-2.68]	1.05 [0.47-2.35]	1.08 [0.57-2.07]	1.29 [0.62-2.68]	0.86 [0.36-2.05]	0.9 [0.25-3.22]	1.36 [0.53-3.49]	1.25 [0.21-7.52]	1.44 [0.72-2.87]	3.10* [1.05-9.14]	0.42 [0.1-1.8]
3	2.07 [0.56-7.66]	3.43* [1.13-7.38]	0.91 [0.35-2.4]	3.76 [0.59-23.96]	0.67 [0.31-1.45]	1.34 [0.62-2.89]	1.18 [0.56-2.49]	0.85 [0.42-1.71]	1.96 [0.89-4.31]	1.05 [0.44-2.51]	0.7 [0.19-2.57]	0.88 [0.28-2.74]	1.42 [0.24-8.3]	1.26 [0.62-2.55]	3.97** [1.41-11.21]	1.06 [0.29-3.91]
4+	2.87 [0.8-10.29]	5.44*** [2.04-6.51]	0.70 [0.28-1.73]	2.92 [0.51-16.55]	0.95 [0.48-1.88]	0.9 [0.44-1.86]	1.17 [0.56-2.42]	1.01 [0.52-1.95]	1.59 [0.82-3.09]	1.04 [0.47-2.3]	1.05 [0.33-3.3]	1.02 [0.39-2.67]	1.14 [0.18-7.32]	1.24 [0.59-2.58]	3.64** [1.27-10.47]	1.18 [0.36-3.82]
Clustered ACEs																
Class 2	1.45 [0.71-2.99]	1.55 [0.93-2.57]	1.26 [0.69-2.31]	1.04 [0.46-2.34]	0.9 [0.56-1.46]	0.97 [0.61-1.53]	1.11 [0.69-1.8]	1.00 [0.66-1.53]	0.93 [0.59-1.47]	1.33 [0.79-2.25]	0.53 [0.22-1.25]	0.65 [0.35-1.24]	1.09 [0.42-2.83]	1.60* [1.06-2.41]	1.88* [1.12-3.14]	0.69 [0.25-1.85]
Class 3	2.8* [1.18-6.64]	2.71*** [1.58-4.63]	0.6 [0.22-1.69]	1.63 [0.7-3.82]	1.17 [0.71-1.92]	0.91 [0.5-1.65]	0.97 [0.58-1.63]	0.7 [0.41-1.2]	1.16 [0.68-1.98]	1.48 [0.8-2.74]	1.13 [0.51-2.49]	1.03 [0.55-1.95]	1.11 [0.36-3.41]	0.95 [0.55-1.67]	2.12** [1.2-3.74]	0.95 [0.37-2.43]
Class 4	2.50* [1.16-5.37]	3.83*** [2.08-7.05]	1.30 [0.61-2.77]	0.69 [0.23-2.05]	1.02 [0.6-1.72]	1.01 [0.55-1.88]	1.35 [0.74-2.47]	0.61 [0.33-1.13]	1.31 [0.78-2.2]	0.74 [0.24-2.31]	1.01 [0.39-2.61]	0.75 [0.37-1.5]	0.75 [0.24-2.33]	1.30 [0.7-2.43]	2.01* [1.07-3.79]	1.99 [0.8-4.97]

***p<.05 **p<.01 ***p<.001; N/A = omitted due to within cell sizes**

The table shows the fold-increase in the odds (OR, odds ratio) of each adult human capital outcome (columns) for each level of ACEs measurement (rows). Models were run separately for each of the 3 ACE measurements and fully adjusted for all covariates, including sex, SES at birth, SES at age 12, SES at age 22, maternal age at birth and maternal and paternal schooling.