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# "Association between Traumatic Life Events and Psychosis: A case-control study in western Kenya"

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## ABSTRACT

Globally close to 70% of the general population has experienced at least one traumatic life event (TLE). Although child and adulthood exposure to TLEs is considered a risk factor for the subsequent development of psychosis, few studies have examined the association between trauma and psychosis in the African population.

We sought to explore the association between TLEs and psychosis in patients with psychotic disorders (N = 254) and individuals without (N = 254). The participants were matched by age and sex. The study was conducted at a national referral hospital, the Life Events Checklist for DSM-5 (LEC-5) was used to obtain data on TLEs, and ethical approval was obtained from the ethics committee.

The proportion of those who experienced TLEs was equal among the cases and controls at about 80%. However, more cases reported that the TLEs happened to them (cases 60.3, p = 0.004).

After multivariate analysis, the following specific TLEs remained statistically significant: Physical assault (aOR = 3.66, 95% CI 2.28–5.48), assaults with a weapon (aOR = 5.26, 95% CI 2.15–10.48), sexual assault (aOR = 4.55, 95% CI 1.08–10.48). The sudden death of a loved one (aOR = 2.33, 95% CI 1.15–4.70) and serious injury/harm to others (aOR = 10.53, 95% CI 1.47–89.37).

## 1. Introduction

Traumatic life events, including physical assault, sexual assault, and accidents/injuries, are a common experience globally, with some studies showing very high prevalence rates between 70 and 80%. For example, the World Mental Health Survey Consortium (WMHS) surveyed 24 countries and noted that more than 70% of the participants reported a traumatic event, with about 30% exposed to 4 or more of the 29 trauma event types assessed [1] (see [Tables 1–3](#), [Figs. 1 and 2](#)).

Traumatic event types vary by region, and countries emerging from conflicts have been shown to have a higher prevalence of trauma, with the sociopolitical environment playing a huge role [2]. For example, a study by Atwoli and colleagues analyzed data from the South African Stress and Health (SASH) in South Africa reported 73.8% of at least one-lifetime trauma exposure and an average of

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4.3 trauma-type occurrences among the study participants [3]. Another study done in Cape Town and Nairobi on trauma exposure in two urban schools reported more than 80% of the participants had exposure to severe trauma either as victims or as witnesses [4].

Psychotic disorders are generally severe and chronic mental illnesses with a relatively high global disease burden, having been ranked among the fifteen top leading causes of disability. The median point prevalence of psychosis in several studies was about 3.89 per 1000 and a 12-month prevalence of 4.03 per 1000 [5].

Some studies have reported that the experience of a specific type of traumatic event, especially interpersonal violence such as sexual assault and physical violence, is linked to a worse trajectory in the psychosis outcome [6,7]. Although not entirely conclusive, childhood exposure to traumatic events [8,9] and adult life events are generally considered risk factors for developing psychosis later in life [10]. However, despite the high level of violence and other potentially traumatic life events in the African continent, the vast majority of the research on the experience of trauma and psychosis was conducted in the developed world. The current study sought to compare the proportion of TLE exposure, identify the types of TLEs, and establish the association between TLEs and psychosis in a population in western Kenya utilizing a case-control design.

## 2. Methodology

### 2.1. Study design

This study was nested within the Neuropsychiatric Genetics of African Population (NeuroGap-Moi) study at the Moi University/MTRH mental health department (IREC/2016/145). The larger study from which data was derived was a multisite case-control study in South Africa, Uganda, Ethiopia, and Kenya. Its focus is mainly on the genetics of patients with neuropsychiatric disorders [11].

Cases were individuals with schizophrenia or bipolar mood disorder (already on follow-up), and controls were age and sex-matched individuals from the same geographic location without a psychotic disorder.

The controls were screened for a history of psychosis using the Psychosis Screening Questionnaire (PSQ), and a score of zero was required for inclusion. The detailed methods were explained by (Stevenson et al., 2019) [11]; here, we only provide a summary.

### 2.2. Study site

The study was conducted at the Moi Teaching and referral hospital outpatient clinic at the Chandaria Cancer and chronic disease Center between January 2020 and March 2021.

Moi Teaching and referral hospital is the second-largest referral hospital in Kenya and serves the entire western region of the country as well as parts of the neighboring countries of Uganda and South Sudan [12].

### 2.3. Recruitment procedure

The patients who came to the mental health clinic on Wednesdays with a working diagnosis (as reviewed by a consultant psychiatrist) of schizophrenia or bipolar mood disorder were approached. Trained research assistants explained the study to them and obtained consent to conduct the interview.

The controls were recruited from individuals who came to the hospital for any other indication other than mental illness, and the procedure of obtaining consent and interview was the same as that of the cases.

**Table 1**

Patient socio-demographic information (n = 508).

Variable	Control (n = 254)	Cases (n = 254)	Total	p-value
<b>Age</b>				
Median	33	34	33	0.233 <sup>w</sup>
IQR	25, 40	26, 45	25, 42.5	
<b>Sex</b>				
Male	125 (49.0%)	125 (49.0%)	250	>0.99 <sup>f</sup>
Female	129 (51.0%)	129 (51.0%)	258	
<b>Marital status</b>				
Married	136 (53.5%)	100 (39.4%)	236	0.002 <sup>f</sup>
Never married	96 (37.8%)	119 (46.8%)	215	
Separated	16 (6.3%)	32 (12.6%)	48	
Widowed	6 (2.4%)	3 (1.2%)	9	
<b>Education level</b>				
Primary	69 (27.2%)	99 (39.0%)	168	< 0.001 <sup>c</sup>
Secondary	76 (29.9%)	93 (36.6%)	169	
Tertiary	109 (42.9%)	62 (24.4%)	171	

<sup>c</sup> Chi-Square.

<sup>w</sup> Wilcoxon rank-sum test.

<sup>f</sup> Fisher's exact test.

## 2.4. Sample size and sampling methods

Consecutive sampling was employed where the patients who came for the mental health clinic appointment and a control group who came to the hospital for any reason other than mental illness were approached every Wednesday until the desired sample size of 254 in each group was achieved.

The sample size was determined using the formula [13] for case-control studies.

$N$  is the estimated minimum sample size for cases.

$$P = (P_1 + P_0) / (1 + C).$$

$C$  is the ratio of controls to cases = 1:1.

$Z\alpha$  is the critical value at  $\alpha$ -level of significance (Type I error ( $\alpha$ ) = 0.05;  $Z\alpha/2 = 1.96$ ).

$Z\beta$  is the critical value for the desired power (Type II error ( $\beta$ ) = 0.2;  $Z\beta = 0.84$ ).

$P_1$  is the proportion of exposure (Type IIB) among cases ( $P_1 = (P_0 * OR) / [1 + P_0 (OR - 1)]$ )

$OR$  is the expected odds ratio (how many times exposure to a traumatic life event is expected to increase the risk of psychosis) = 1.8.

$P_0$  = proportion of exposure among controls = 0.705 (based on World Mental Health Survey Consortium (WMHS) [1]).

Using the above formula, the minimum sample size was 508 (254 cases and 254 controls).

## 2.5. Eligibility criteria

### 2.5.1. Inclusion criteria

**2.5.1.1. Cases.** Working diagnosis (as shown by medical record review) of schizophrenia or Bipolar Mood Disorder. Age above 18 demonstrates an ability to consent by scoring 15 and above on the UBACC (the University of California, San Diego Brief Assessment of Capacity to Consent).

**2.5.1.2. Controls.** Age above 18 years. Willingness and ability to consent by scoring 15 and above on the UBACC. Has never been diagnosed and/or treated for mental illness (Score of zero on the psychosis screening questionnaire (PSQ)).

### 2.5.2. Exclusion criteria

**2.5.2.1. Cases.** Patients who exhibit acute, intrusive levels of psychiatric symptoms. Acute intoxication of alcohol or other substances. Persons were not fluent in English or Kiswahili and persons who are current psychiatric inpatients.

**2.5.2.2. Controls.** Acute intoxication of alcohol or other substances and persons not fluent in English or Kiswahili.

## 2.6. Data collection

A structured questionnaire was used to collect demographic data, including age, sex, education level, and marital status.

The University of California, San Diego Brief Assessment of Capacity to Consent (UBACC) was used to assess the participant's ability to provide consent. It is a 10-item tool with questions focusing on understanding the study protocol. With a maximum score of 2 in each item, participants who scored more than 15 were included in the study [14]. It is a validated tool currently in use in Kenya [11,15].

**Table 2**

Types of traumatic life events among the cases and controls.

Event	Control (N = 254)	Cases (N = 254)	OR	95%CI
Natural disaster	21 (8.3%)	21 (8.3%)	1	0.53–1.88
Fire/explosion	27 (10.6%)	29 (11.4%)	1.08	0.62–1.89
Transportation accident	58 (22.8%)	55 (21.6%)	0.92	0.61–1.42
Serious accident	24 (9.4%)	29 (11.4%)	1.23	0.70–2.19
Exposure to the toxic substance	2 (0.8%)	1 (0.4%)	0.50	0.04–5.53
Physical assault	37 (14.6%)	95 (37.4%)	3.50	2.28–5.40
Assault with a weapon	8 (3.1%)	34 (13.4%)	4.75	2.15–10.48
Sexual assault	4 (1.6%)	13 (5.1%)	3.37	1.08–10.48
Other unwanted sexual experience	3 (1.2%)	7 (2.8%)	2.37	0.61–9.27
Exposure to a war-zone	41 (16.1%)	33 (13.0%)	0.78	0.47–1.27
Captivity	4 (1.6%)	1 (0.4%)	0.25	0.03–2.23
Life-threatening illness/injury	94 (37.0%)	45 (17.7%)	0.37	0.24–0.55
Severe human suffering	14 (5.5%)	15 (5.9%)	1.07	0.51–2.28
Sudden, violent death	26 (10.2%)	17 (6.7%)	0.63	0.33–1.19
The sudden death of someone close to you	14 (5.5%)	26 (10.2%)	1.95	0.99–3.84
Serious injury/harm you caused to someone else	1 (0.4%)	11 (4.3%)	11.45	1.47–89.38
Any other very stressful event/experience	13 (5.1%)	13 (5.1%)	1	0.45–2.20

The Life Events Checklist for DSM-5 (LEC-5) was utilized to obtain data on the TLEs. It is a 17-item self-report tool that screens for potentially traumatic events in a patient's lifetime. It assesses exposure to sixteen events that may result in distress and one additional item that sets for any other extraordinary stressful event. It was developed by the national center for posttraumatic stress disorder (PTSD) [16].

The Psychosis Screening Questionnaire was used to screen for psychotic experiences among the controls. It is a scale developed to screen for psychotic symptoms in the individual's lifetime and the past year. It has five (5) probe questions about hypomania, thought insertion, paranoid delusions, strange experiences, and hallucinations. If the respondent answers in the affirmative to any questions, they screen positive for psychosis [35].

## 2.7. Data management

The data was collected electronically using a tablet and stored in a database cloud. Cleaning, validation, and quality control were done before the analysis commenced.

## 2.8. Data analysis

Frequency and corresponding proportions were used to summarize categorical variables such as; sex, education level, marital status, the prevalence of TLEs, and types of TLEs. While, mean/median and their corresponding standard deviation/interquartile range were used to summarize numerical variables such; as age and frequency of TLEs. The results are presented in tables, charts, and pros. Chi-square or Fisher's exact test was used to compare proportions where the Chi-square value and its corresponding degree of freedom and p-value were reported. Wilcoxon rank-sum test was used to compare the difference in frequencies of TLEs between the study group and the control group.

## 2.9. Ethical consideration

Approval to conduct the study was obtained from the Moi Teaching and Referral Hospital/Moi University School of Medicine Institutional Research and Ethics Committee (IREC/2019/135 FAN:0003395). Permission was also obtained from the management of MTRH and the National Commission for Science, Technology, and Innovation (NACOSTI) License No: NACOSTI/P/191553.

Written informed consent was obtained from all the participants before they were enrolled in the study. Confidentiality was maintained by using assigned numbers instead of participants' names or other identifiers.

## 3. Results

Cases and control were matched by age and sex. Compared to cases, controls had a significant ( $p = 0.002$ ) higher proportion who were married (39.4% vs. 53.5%) and a low proportion of those separated (controls 6.3% vs. cases 12.6%) and those never married (controls 37.8% vs. cases 46.8%). On the other hand, compared to controls, cases were significantly ( $p < 0.001$ ) less likely to have achieved a higher level of education (tertiary education: controls 42.9% vs. cases 24.4%).

### 3.1. The proportions of individuals who experienced traumatic life events among cases and controls

The proportion of those who had experienced at least one traumatic life event (happened to them and/or witnessed) was almost equal among the cases and controls, [cases 204 (80.3%) vs. controls 202 (79.5%)], and this was found not to be statistically significant.

Cases had a higher proportion of participants who reported that the traumatic life event happened to them (cases 60.3% vs. controls 46%), while the control had a higher proportion who witnessed trauma (controls 54%.vs cases 39.7%). This had a strong statistical significance ( $p=0.004$ ). (Chi Square Test).

**Table 3**

Multivariate analysis of the association between TLEs and psychosis controlling for marital status and education level.

Variable	uOR	95% CI	p-value	aOR	95% CI	p-value
Married	1			1		
Never married	1.69	1.16–2.44	0.006	2.24	1.44–3.49	0.001
Separated	2.72	1.42–5.22	0.003	2.78	1.33–5.81	0.007
Widowed	0.68	0.17–2.78	0.592	0.77	0.17–3.54	0.741
Primary	1			1		
Secondary	0.85	0.55–1.31	0.470	0.67	0.41–1.10	0.111
Tertiary	0.40	0.26–0.61	<0.001	0.26	0.15–0.44	<0.001
Physical assault	3.50	2.28–5.40	<0.001	2.39	1.43–4.00	<b>0.001</b>
Assault with a weapon	4.75	2.15–10.48	<0.001	2.31	0.92–5.79	0.074
Sexual assault	3.37	1.08–10.48	0.036	3.53	0.91–13.63	0.067
Life-threatening illness/injury	0.37	0.24–0.55	<0.001	0.34	0.22–0.55	< <b>0.001</b>
Sudden death of someone close to you	1.95	0.99–3.84	0.051	1.99	0.92–4.29	0.082
Serious injury/harm you caused to someone else	11.45	1.47–89.38	0.020	7.85	0.93–66.15	0.058

The average number of traumatic life events was significantly ( $p=0.047$ ) higher (2) among the cases compared to controls (1). (Mann-Whitney  $U$  Test).

Regarding the types of traumatic events in the specific categories, the most common ones among the cases were; Physical assault (37.4%,  $n = 95$ ), assault with a weapon (13.4%,  $n = 34$ ), the sudden death of a loved one (10.2%,  $n = 26$ ), sexual assault (5.1%,  $n = 13$ ), and serious injury/harm caused to someone else (4.3%,  $n = 11$ ).

Among the controls, the following traumas were prevalent; life-threatening illness/injury (37.0%,  $n = 94$ ), transportation accidents (22.8%,  $n = 58$ ), exposure to a war zone (16.1%,  $n = 41$ ), and witnessing of sudden violent death (10.2%,  $n = 26$ ). The distribution of the rest of the traumatic events categories was almost equal among the two groups.

After a logistic regression analysis was done to determine the association between TLEs and psychosis while adjusting for confounders (controlling for marital status and education level), the following specific traumas remained statistically significant.: Physical assault, where the cases reported an almost four-fold likelihood of being assaulted compared to the controls (aOR = 3.5, 95% CI 2.28–5.48). Cases have also reported a nearly five times possibility of assaults with a weapon than their control counterparts (aOR = 4.75, 95% CI 2.15–10.48). Cases were three times more likely to experience a sexual assault than were for the controls (aOR = 3.37, 95% CI 1.08–10.48). Cases were twice as likely to experience the sudden death of a loved one than the controls (aOR = 1.95, 95% CI 0.99–3.84). Similarly, cases were more likely to cause serious injury/harm to others than controls (aOR = 10.53, 95% CI 1.47–89.37). However, Cases were less likely to report a life-threatening illness/injury than the controls (aOR = 0.37, 95% CI 0.24–0.55).

#### 4. Discussion

In the current study, the proportion of those who had experienced at least one TLE was equal among the cases and controls. This might be because the rates of trauma in the general population are so high that it's unlikely to have a difference between the cases and controls. Notwithstanding the lack of case-control studies that have compared the proportion of traumatic events, specifically in patients with psychosis and those without, our results resemble other studies that reported approximately 70–80% of the studied participants in the general population as having experienced trauma. In agreement with this finding is the world mental Health survey consortium (WMHS), whose survey in 24 countries spanning six continents noted that more than 70% of the participants reported experiencing a traumatic event [1].

In Australia, a study that utilized data from the Australian national survey of mental health and Well-being documented that 74.9% of Australians had experienced at least one potentially traumatic event in their lifetime [17]. Similarly, in South Africa, it was reported that 73.8% of the participants had experienced trauma [3]. Another study done in Cape Town and Nairobi on trauma exposure in 2 urban schools reported more than 80% of the students had exposure to severe trauma either as victims or as witnesses [4].

Regarding the types of traumatic events in the specific categories, the most common ones among the cases were; Physical assault, assault with a weapon, sudden death of a loved one, sexual assault, and serious injury/harm caused to someone else. A similar finding among respondents with psychosis was the study by the World mental health survey, in which people with psychotic experiences reported a higher prevalence of; unexpected death of a loved one, witnessing death, being mugged or threatened with a weapon [18].

In the South African study, the most common traumatic events among the participants were physical violence, the death of a loved one., accidents, and witnessing trauma [3]. Given the wide variation in traumatic event types reported by various studies and community surveys coupled with the lack of case-control studies, it is difficult to provide contrasting literature on traumas experienced by people with psychosis and those without. However, the difference in the TLEs reported by the cases and the controls may shed some light on the mechanisms and the link of these specific traumas to the whole psychosis spectrum.

Individuals with psychotic disorders are also significantly more likely to report specific types of TLEs histories, such as sexual assault, than the controls or their siblings. This, therefore, indicates that the differences in trauma exposure may be the reason for their exhibiting psychotic symptoms [19].

It is worth noting that very few studies have attempted to show whether specific traumatic event types are associated with psychosis. As a novel finding in this region and among the African population, the following variables stood out during our analysis concerning individuals with psychosis: physical assault, assault with a weapon, sexual assault, sudden death of someone they knew, and caused serious injury/harm to some else, as discussed below:

**Physical assault:** In this study, people with psychosis were four times more likely to be physically assaulted than were for those

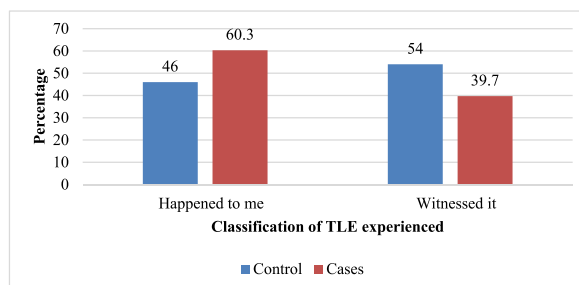


Fig. 1. Proportions by mode of traumatic life events. Chi Square Test.

without psychosis. These results are consistent with the study in the UK, in which cases were more likely than controls to report exposure to at least one moderate or marked physically threatening difficulty (cases 53.6% vs. controls 25.6%) that is, reported difficulties were associated with 4-fold increased odds of psychosis (partially adjusted OR 4.69, 95% CI 2.92–7.53). These threatening and intrusive life events and difficulties are common among individuals with psychosis and may contribute to the development of psychotic disorders [20]. In another study, there were high odds of interpersonal violence which include; witnessing physical violence (OR = 2.1, 95% CI 1.8–2.4) and being beaten up (OR = 2.1, 95% CI 1.6–2.7) [21]. It is not possible to ascertain from our results that physical assault is a cause of psychosis or a consequence of psychosis. However, the physical violence meted out on people with psychosis could be because of them exhibiting florid psychotic symptoms; the society sometimes responds violently towards them, more so when they are brought to the hospital or kept locked up at home [22].

**Assaults with a weapon:** Patients with psychosis also reported a more than five times likelihood of being assaulted with a weapon than their control counterparts. These findings were similar to those echoed by Beards, who found that cases were around 3-times more likely than controls to report exposure to at least assault with a weapon in the year before onset (cases 48.6% vs. controls 21.5%; partially adjusted OR 3.52, 95% confidence interval [CI] 2.20–5.64). Further, there was some evidence that the odds of psychosis increased with each additional traumatic life event [20].

**Sexual assault:** In the current study, people with psychosis were almost five times more likely to experience a sexual assault than were for the controls. While this study was looking at the temporal association between sexual assault and psychosis, other studies have examined the development of psychotic symptoms after sexual assault. One study by the World mental health survey reported that the participants who reported sexual abuse (rape) had a fivefold increased odds of developing psychosis (OR = 4.9, 95% CI 2.5–9.5) [18].

Another study [23] conducted on the general population in the UK found that the largest odds ratio for the risk of developing psychosis after a logistics regression was sexual abuse (OR = 2.9, 95%CI, 1.30–6.40). This could be attributed to social isolation among individuals with psychosis [24]. Self-isolation is one of the major factors that lead to sexual assault and increases vulnerability.

The experience of sexual assault has several other implications for people, including the risk of sexually transmitted diseases, unplanned pregnancy, and even injuries. Many of these victims of sexual assault experience severe forms of distress where their lives get disrupted and even become dissociated from reality [25].

**The sudden death of a loved one:** People with psychosis reported more than twice experiencing the sudden death of a loved one more than the controls. A study by Keyes and colleagues reported a similar finding as ours in which the unexpected death of a loved one was one of the most common traumatic events reported by the participants and regarded as the worst trauma by many respondents. Regardless of the occurrences of other TLEs in the lifetime of an individual, the study reports more than double odds (OR = 2.14, 95% CI 1.19–3.83) of developing a mental illness presenting with psychosis in their lifetime for people above the age of 30 years after controlling for other mental illnesses, [26].

The sudden death of a loved one has adverse and varied consequences on the bereaved, where the majority of mental illnesses including psychosis get elevated with a poor or slower recovery trajectory than when compared to death from an expected or natural cause [27].

**Serious injury/harm to others:** People with psychosis were more likely to cause serious injury/harm to others than controls. A similar finding was a meta-analysis [28] that reported a significant association between psychosis and physical violence and that patients with psychosis had a 49%–68% increase in odds of violence to others. In consonant with our finding is a systematic review and meta-analysis [29], among patients with first-episode psychosis that reported a significant number of patients seeking treatment for a first-episode psychosis had committed an act of violence, sometimes involving serious injuries to others [29].

There is a tendency to associate individuals with psychosis and severe mental illness with violent behavior, which significantly advances the fear and stigma facing such patients [30]. When in the real sense, the vast majority of violent acts are orchestrated by people in the general population without mental illness [31].

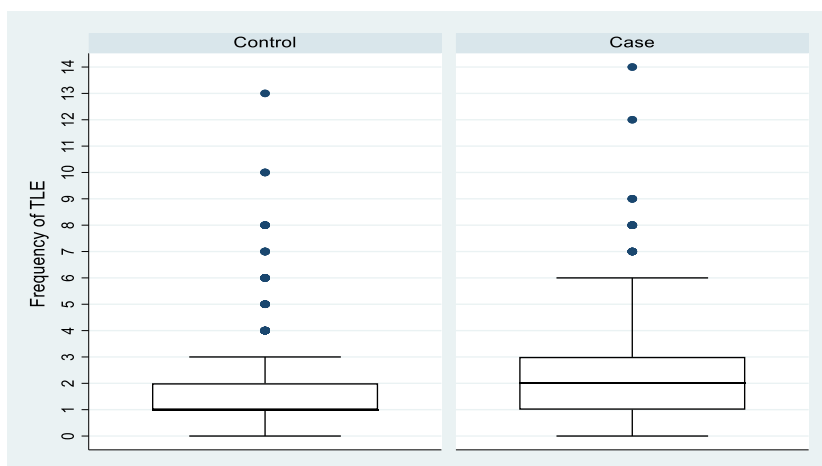


Fig. 2. Frequencies of traumatic life events among the cases and controls.

**Life-threatening injury/illness:** People with psychosis were less likely to report the occurrence of a life-threatening illness/injury (OR = 0.37, 95% CI 0.24–0.55). In the world mental health survey study, there was no statistical difference between individuals with psychosis and the general population in terms of their experience of a life-threatening illness at multivariate analysis. (OR = 1.2, 95% CI 1.0–1.5), [18]. Individuals with psychosis reporting fewer injuries might be because they are experiencing other major traumas and so much violence more than people without psychosis that it has become normalized to them the injuries they get on the way. Secondly, at the time of the injuries or illness, they might not have had insight and, therefore, were unable to recall.

## 5. Limitations

This study has strengths like being a case-control study where the controls were drawn from the same geographical setting as the cases and having them excluded for any mental illnesses to avoid an overlap of TLEs that may be common among the mentally ill patients. We also used a tool with a good range of traumatic event types.

Firstly, the study was hospital-based, and the findings might not be easily generalizable to the general population. Secondly, data on TLEs was collected retrospectively; thus, a recall bias might have occurred. However, the participants were required to give any traumatic event that happened in their entire life and were not limited to a specific timeframe requiring a vivid remembrance of the turn of events.

Thirdly, the study was nested within and utilized data from a larger multisite case-control study (NeuroGAP-Moi study); therefore, the researchers were limited by the eligibility criteria employed in the recruitment of participants of the parent study. This meant that some variables, like the inclusion of other disorders presenting with psychosis and the site of recruitment of controls, could not be changed in this sub-study.

## 6. Conclusion

The study found a high proportion of exposure to traumatic life events among people with psychosis and those without, and an increased number of individuals with psychosis directly experiencing trauma (happened to them).

The TLE types that are more common among patients with psychosis include - physical assault, assault with a weapon, sexual assault, experiencing the sudden death of a loved one, and causing serious injury/harm to someone else.

Among the controls, the following traumas are prevalent; life-threatening illness/injury, transportation accidents, exposure to a war zone, and witnessing a sudden violent death.

On average, the number of traumatic life events is significantly higher among people with psychosis than among controls.

## 7. Recommendations

We recommend that healthcare workers at all levels take some time to assess for TLEs in individuals presenting with psychosis-related concerns, as TLE histories may be essential in treating psychosis. Given the association between TLEs and psychosis, community and policy efforts to prevent the incidence of traumatic life experiences such as physical assault, assault with a weapon, and sexual assaults, as well as measures to reduce stigma and educate the public on the care for people with psychosis needs to be put in place as it is imperative for public health.

### Author contribution statement

Mohamed Aden Hillow; Lukoye Atwoli; Edith Kamaru Kwobah: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

### Data availability statement

Data will be made available on request.

### Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

### Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.heliyon.2023.e18144>.



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