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Social determinants of injury-attributed mortality in Papua New Guinea: new data from the Comprehensive Health and Epidemiological Surveillance System

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ABSTRACT
Objective This study reported the prevalence and sociodemographic distribution of mortalities attributed to injuries in Papua New Guinea (PNG).

Setting As part of a longitudinal study, mortality data were collected from the population who live in eight surveillance sites of the Comprehensive Health and Epidemiological Surveillance System, established in six major provinces in PNG. Verbal autopsy (VA) interviews were conducted by the surveillance team with close relatives of the deceased, using the WHO 2016 VA instrument from January 2018 to December 2020.

Participant and Intervention Mortality data from 926 VA interviews were analysed, using the InterVA-5 diagnostic tool to assign specific cause of death (COD). Distributions of injury-attributed mortality were calculated and multinomial logistic regression analyses were conducted to identify sociodemographic factors and provide ORs, 95% CIs of estimates and p values.

Result Injury-attributed deaths accounted for 13% of the total deaths recorded in the surveillance population, with the highest proportion in Madang (22%), followed by Port Moresby and Central Province (13%). Road traffic accidents were the leading COD, accounting for 43% of the total injury-attributed deaths, followed by assaults (25%) and accidental falls (10%). Young adults (aged 15–24 years) accounted the largest proportion of injury-attributed deaths (34%) and were nearly six times more likely to die from injuries than those aged 75+ years (OR: 5.89 (95% CI: 1.01 to 3.99); p=0.048). Another significant sociodemographic factor associated with the increased injury-attributed mortalities included urban versus rural residence (OR: 2.0 (95% CI: 1.19 to 3.36); p=0.009). No other significant differences were identified in this study.

Conclusion Young adults, particularly those who live in urban areas, were at the highest risk of dying from injuries. Public health policies and interventions are needed to reduce premature mortality from injuries in PNG.

INTRODUCTION
Sustainable Development Goal (SDG) target 3.6 aims to halve the number of global deaths and injuries from road traffic accidents by 2030 with an associated indicator (3.6.1) to report the death rate due to road traffic injuries.1 Social and contextual risk factors play a role in the occurrence of injuries.2 Understanding these socioeconomic factors is important to inform policies and interventions to reduce mortality from road traffic injuries. Studies in high-income countries reported major injuries clustered in populations with lower levels of education, more people of younger ages and with lower

STRENGTHS AND LIMITATIONS OF THIS STUDY
⇒ This study reported mortality data from the population who lived within catchment areas of the Comprehensive Health and Epidemiological Surveillance System, including eight surveillance sites representing both urban–rural sectors of four geographical regions of Papua New Guinea.
⇒ The WHO 2016 verbal autopsy (VA) interview instrument was used to collect mortality data via VA interviews with close relatives of the deceased, conducted by the community-based surveillance team in the period 2018–2020.
⇒ The InterVA-5 analytical tool was used for cause of death (COD) analysis and assigned specific COD for more than 900 deceased and categories aligned with the International Classification of Diseases, 10th Revision.
⇒ Household wealth index was constructed using dimension reduction factor analysis and linked with mortality data, allowing in-depth analyses of sociodemographic factors associated with mortalities from injuries.
⇒ Mortality data used in this study were not representative of all deaths that occurred in the communities during the data collection period and might be biased due to recall, especially for the small numbers of observations on specific CODs from injuries that require interpretation with caution.
income levels. Studies in low/middle-income countries reported negative associations between socioeconomic status and injury among adolescents.

Papua New Guinea (PNG) is located just south of the equator and 160 km north of mainland Australia. PNG is the largest nation in the South Pacific region with a total population of approximately 8 million in 2020. With 38.2% of the population under the age of 15 years, PNG has a young population. PNG consists of 22 provinces, divided into four geographical regions: Highlands, Southern, Momase and Islands. More than 85% of the population live in rural areas and widely dispersed across the vast rural areas, where majority of the population is involved in subsistence-based agriculture. PNG is classified as a lower middle-income country and the country has great potential to improve its socioeconomic development status with enriched natural resources such as land, agriculture, forestry and fisheries. The mining and energy sectors contribute approximately 80% of the total export revenue of the country. The mortality rate in PNG has declined in recent years, along with an increase in life expectancy. PNG has experienced dramatic social and economic changes since its independence in 1975.

Recent socioeconomic development was hypothesised as a key driver of the health transition in PNG, which is characterised by an epidemiological shift in causes of death (CODs) from infectious diseases to non-communicable diseases. This has contributed to an increase in injury mortality. This epidemiological shift could have resulted in an increase in the burden of disease and pressure on the health system, particularly at the primary health level. However, social determinants of injury mortality are poorly understood. The distribution of injury mortalities across urban–rural locations, age groups, sexes and socioeconomic statuses of the deceased persons, the leading CODs and sociodemographic factors associated with the risks of dying from injuries are not known. Answers to these questions will provide a better understanding of injury mortality and insights into public health policies and practices to protect the population from premature mortality from these CODs, contributing to the achievement of SDGs in PNG.

RESEARCH METHOD

Data source

Mortality surveillance data were extracted from the Comprehensive Health and Epidemiological Surveillance System (CHESS), operated by PNG Institute of Medical Research (PNGIMR) on the basis of the integrated Health and Demographic Surveillance System established in the period 2010–2017. CHESS was designed as a population-based longitudinal follow-up cohort study, with an aim to provide up-to-date data series for monitoring and evaluation of the impact of socioeconomic development programmes and health interventions on the health of the population at the national and subnational levels. The design and methods of CHESS have been published elsewhere.

CHESS covers approximately 80 000 people living in the catchment areas, equivalent to 1% of the total population of PNG in the period 2018–2022. The system covers both rural and urban populations, with about 75% in rural and 25% in urban areas, comparable with the national rural–urban population distribution for the period 2018–2022. CHESS was established in six main provinces of PNG: Port Moresby, Central Province, Eastern Highlands Province, East New Britain, East Sepik Province and Madang Province. Catchment area includes eight surveillance sites which are matched in pairs, four urban and four rural sites, representing the urban–rural sectors of provinces, where the sites were established.

Surveillance setting

Port Moresby is the National Capital District, located in the Southern Region of PNG. The Port Moresby surveillance site is located in Hohola, an urban suburb with a population coverage of approximately 5000 people. The people in Hohola site speak mainly English, and also Pidgin and Motu. The adult population is mostly comprised of middle working-class people. Their main sources of income are from public sector and private sector, largely minitrade stores. This surveillance site has better access to public services such as electricity, water supply and healthcare services. Three primary schools and one secondary school are located within the surveillance site.

Central Province is also located in the Southern Region. The surveillance site is established in Hiri, a peripheral urban area, 1-hour drive in the west of Port Moresby. Hiri site was designed as a semiurban site, paired with Port Moresby urban site, comprising four traditional Motuan villages of Porebada, Boera, Papa and Lealea, located along the north-west coastline and surrounding a liquefied natural gas plant, open in the early 2010s. Hiri site covers a population of approximately 15 000. Most of people speak English, Pidgin and Motu. The recent improvement in road infrastructure and urbanisation has changed the traditional lifestyle of the local people. This site has better access to government services such as electricity, water supply, education and healthcare than other...
Eastern Highlands Province is located in the Highlands Region. Two surveillance sites in Eastern Highlands Province are established in Goroka (urban site) and Asaro (rural site). The population coverage of these two sites was approximately 20,000 people in 2021. The major languages spoken are Tokples and Pidgin, the most common local languages in PNG. These sites were classified in the middle socioeconomic development status. People are primarily subsistence farmers. Cash incomes are from family farming of coffee and the informal employment sector such as selling of garden products.

Three primary health facilities were included in CHESS as sentinel sites for surveillance of morbidity in the sites. Ten public and private schools provide primary and secondary education services for children who live in the sites.

East New Britain is located in the Islands Region and currently operates two surveillance sites in Kokopo (urban site) and Baining (rural site), with the population coverage of approximately 10,000 and 33,000, respectively. Kokopo is a new provincial centre, approximately 500 km from the national industrial port city of Lae on the mainland. The population living in the site has access to roads, electricity and water supply. There are three primary schools and one secondary school, and two main primary health facilities within Kokopo site. The people of Baining are mostly subsistence and cash-crop farmers of cocoa along with other agriculture products. They live mostly in semipermanent houses in traditional villages with the minority having access to electricity. People have access to primary healthcare services, provided by four public health facilities. There are five primary schools and two secondary schools in Baining site.

East Sepik Province is located on the northern coastline of PNG’s mainland, and part of the Momase Region. A new surveillance site was established in Maprik (rural site) in 2018, with the current population coverage of approximately 12,400 people. Sepik Highway connects Maprik site, which is about a 2-hour drive from Wewak Provincial Township of East Sepik Province. The economy in East Sepik Province is mostly agriculture based with large projects on oil palm, cocoa and vanilla production. The population living in these two sites speaks mostly Pidgin and Tokples. Most of the residents who live in these sites are subsistence farmers. Their main source of income is the cash cropping of cocoa, selling of garden products at the local markets and some are employed in the formal employment sector. Residents in Maprik site can access primary healthcare services at five primary public health facilities. There are two primary and two secondary schools in Maprik site.

Madang Province is also located in Momase Region. The catchment area of Madang surveillance site includes approximately 5,000 people in Newtown, a suburban area of Madang Township. Newtown urban site is matched with Maprik rural site. The surveillance population are mostly low-income to middle-income earners. Their incomes are mostly through formal jobs and small businesses in roadside markets. The population has access to the basic services of water supply, electricity and road connections. The site includes 2 health facilities and 10 private and public schools.

**Data collection**

The WHO 2016 verbal autopsy (VA) instrument was used to collect mortality data via VA interviews with close relatives of the deceased. This instrument was developed based on the existing VA tools, offering considerable improvements in terms of efficiency and effectiveness, compared with the previous VA tools. The instrument was adapted by PNGIMR’s CHESS team in 2017 with modifications for optimal use in the local context of PNG. In addition to standard questions about the signs and symptoms the deceased experienced prior to death, a data module on the household and individual identification information, including household global positioning system (GPS) data, was included in the interview questionnaire. This allowed to identify the deceased individuals in the communities, and linked their mortality data with household socioeconomic demographic data available from the CHESS database. The instrument was installed in smartphones and tablets, allowing interviewers who do not have a medical background to facilitate VA interviews. VA interviews were conducted between March 2018 and September 2020 (2.5 years) by the CHESS demographic team.

**Data quality control**

Data quality control procedure was applied throughout the data collection and processing. Data reporters are local people living in their villages who were involved in identification of deaths that occurred in the communities. Given the local background and social network, data reporters were aware of deaths in their villages and had access to the households to collect further information, as required. They identified deaths through home visits, reported deaths to surveillance team leaders and pre-arranged VA interviews at a time and location convenient for the participants. VA interviews were often conducted in Pidgin and Motu languages and by national scientific officers, who were based in the CHESS field offices. Some VA interviews required more than one home visit to complete.

VA data were first checked by site managers. Identified mistakes were double-checked with the team leaders for clarifications and corrections before the electronic data files were sent to PNGIMR main office in Goroka for processing. VA datasets were uploaded to the CHESS database by the database manager and stored on the PNGIMR’s secured server. About 10% of the VA interviews were randomly checked in the second round of quality control. Raw VA dataset was extracted from the database using structured query language (SQL) - process maker scripts with inclusion and exclusion criteria.
CHESS principal investigator oversaw the quality control and conducted the final check of VA dataset using various statistical tests. Key indicators of data quality were assessed, including completeness, missing values, internal consistency and outliers. Corrections were made throughout the data cleaning process as needed. The clean VA dataset consisting of 353 variables plus identifiers was converted into InterVA-5 input format (cvs.file) for inclusion in the InterVA-5 model for COD analysis.24

COD and statistical analyses
The InterVA-5 analytical program was used to assign specific CODs for each of the deceased.24 This computer-based program can assign 64 specific CODs and categories, which are aligned with the International Classification of Diseases, 10th Revision, Clinical Modification (ICD-10-CM) for injury, poisoning and other external causes, which are coded from S00 to T88 and from V00 to Y99.24,25

The mortality dataset including VA and COD data was linked with household socioeconomic dataset, by using household and individual unique ID codes.5 Household wealth scores were calculated for every deceased individual, based on key household socioeconomic variables on housing conditions, access to water and sanitation, and household assets, using dimension reduction factor analysis method. Household wealth scores were grouped into five quintiles: from the poorest to poor, middle, richer and the richest.5 A new binomial variable on injury-attributed mortality was created, with ‘Yes’ for deaths from injuries and ‘No’ for deaths from all other causes.26 This variable was stratified by sex and age, province, urban–rural residence and household wealth quintile of the deceased to show the distribution of deaths (number and percentage).

Multinomial logistic regression (MLR) was used to identify the associated factors of injury mortality, and to predict the risk of mortality from injuries across subpopulations. Injury mortality was included in the MLR model as a dependent variable while socioeconomic demographic variables were used as independent factors. Significant factors retained in MLR model included urban–rural sector, province, sex, age at death (0–4, 5–14, 15–24, 25–34, 35–44, 45–54, 55–64, 65–74 and 75+ years) and household wealth quintile. Main effect was selected and the last categories of independent variables were designated as the reference categories to produce maximum likelihood estimates of ORs, 95% CI and p value (<0.05 was used as significance). All statistical analyses were conducted using SPSS (V.20).

Patient and public involvement
No patient involved.

RESULTS
Assuming the crude death rate of 6.5 per 1000 population reported in PNG for the period 2019–2020,25 with the population coverage of approximately 80,000 people in 2021 and about 80% of deaths that occurred in the communities, one can expect 1040 deaths across the surveillance sites over the 2.5 years (0.0065×80000×0.8×2.5). There were 1021 deaths identified in CHESS, accounted for 98.2% of the estimated number of deaths. This is a good indication of completeness of the mortality data used in this study. Among the deaths identified, informed consent was obtained for conducting 1003 VA interviews, resulting in a participation rate of 98%. All VA interview data were included in the Inter VA-5 model for COD analysis and 926 deaths were successfully assigned specific CODs, resulting in a success rate of 92%. A total of 77 deaths (8%) were not assigned COD because they were excluded from the InterVA-5 modelling due to poor data quality.

Distribution of injury mortality
The distribution of injury mortality by sociodemographic characteristics of the deceased is presented in table 1. A total of 118 deaths from injuries were identified from the mortality data, accounting for 12.8% of the total deaths recorded in the surveillance population. Mean age at death due to injuries was 42.9 years (±21.8), significantly lower than the mean age at death from other diseases (49.4 years±23.6) (p=0.005). The highest proportion of deaths from injuries was among young adults (15–24 years) (33.9%), followed by children (5–14 years) and adults (25–34 years), 19% and 17%, respectively. The proportion of deaths from injuries in males was 16%, higher than females (9%). About 17% of deaths in urban areas were due to injuries, compared with 11% in the rural areas. Central Province reported the highest number of deaths from injuries (39 deaths), but Madang reported the highest proportion of deaths from injuries (22%), almost more than twice the other provinces. The proportion of deaths from injuries varied across household wealth quintiles, from the lowest level (9%) in the middle class to the highest level (17%) in the poor class.

Leading CODs from injuries
The leading CODs from injuries by sex of the deceased are shown in figure 1. The three leading CODs from injuries among the population were road traffic accidents, assaults and accident falls. However, leading CODs from injuries were different between two sexes. For males, road traffic accidents were the leading COD, followed by assaults and drownings. Assaults, road traffic accidents and accidental falls were the three leading CODs among females. Notably, road traffic accidents were six times higher in males than females and comprised nearly half of all male deaths from injuries. By contrast, assaults comprised over one-third of female deaths but only one-fifth of male deaths.

Sociodemographic factors of injury mortality
The sociodemographic factors associated with injury-attributed mortality are shown in table 2. A total of 665
deaths were eligible for inclusion in the MLR modelling. Key sociodemographic factors of mortality from injuries remained in the model including age, sex, urban–rural residence, province and household wealth quintile. Compared with the population aged 75 years and above, schoolchildren (aged 5–14 years) were four times more likely to die from injuries (OR: 3.9 (95% CI: 1.1 to 14.3); p=0.036), while young adults (aged 15–24 years) were nearly six times more likely to die from these causes (OR: 5.9 (95% CI: 2.2 to 16); p=0.000). Males were twice more likely to die from injuries than females (OR: 2.0 (95% CI: 1.2 to 3.4); p=0.009). Compared with the rural population, those from urban areas were twice as likely to die from injuries (OR: 2.0 (95% CI: 1.0 to 3.99); p=0.048).

However, the risk of dying from injuries was not significantly different across provinces and household wealth quintiles.

### DISCUSSION

VA interviews were conducted using the WHO 2016 VA instrument to collect mortality data for COD analyses. The InterVA-5 COD analytical tool was used to assign specific CODs for each deceased. The InterVA-5 program assigned CODs and categories aligned with the ICD-10-CM. There is no database on mortality at the national level in PNG. Hence, CHESS is among the few databases currently available in the country providing mortality

### Table 1 Distribution of mortalities from injuries versus other causes of death (CODs) by age and sex, urban–rural sector, province and household wealth quintile, PNGIMR’s CHESS, 2018–2020

| Age group | Injury-attributed CODs* | Other CODs | All CODs |
|-----------|------------------------|------------|----------|
| 0–4       | 42.9 (21.8)            | 49.4 (23.6) | 48.6 (23.4) |
| 5–14      | 3 (4.5%)               | 64 (95.5%)  | 67 (100.0%) |
| 15–24     | 21 (33.9%)             | 41 (66.1%)  | 62 (100.0%) |
| 25–34     | 17 (17.2%)             | 82 (82.8%)  | 99 (100.0%) |
| 35–44     | 18 (19.1%)             | 76 (80.9%)  | 94 (100.0%) |
| 45–54     | 16 (10.7%)             | 133 (89.3%) | 149 (100.0%) |
| 55–64     | 16 (9.4%)              | 154 (90.6%) | 170 (100.0%) |
| 65–74     | 9 (6.3%)               | 134 (93.7%) | 143 (100.0%) |
| 75+       | 13 (11.5%)             | 100 (88.5%) | 113 (100.0%) |
| Total     | 118 (12.8%)            | 805 (87.2%) | 923 (100.0%) |

### Note

*Injury-attributed CODs include road traffic/other transport accidents, accidental fall, drowning and submersion, exposure to smoke and fire, venomous animals and plants, poisoning, noxious substance, intentional self-harm, assault, force of nature, other and unspecified external CODs.

†Difference between mean ages at death was significant with a p value of 0.005.

CHESS, Comprehensive Health and Epidemiological Surveillance System; EHP, Eastern Highlands Province; ENB, East New Britain; ESP, East Sepik Province; PNGIMR, Papua New Guinea Institute of Medical Research; POM, Port Moresby.
data for COD analyses. We found that in PNG, the leading CODs from injuries were road traffic accidents, followed by assaults and accident falls. These leading CODs varied across sociodemographic characteristics of the deceased. While road traffic accidents were the leading COD among males, assaults were the leading COD among females.

Road traffic accidents were the leading COD among school-aged children and young adults, particularly among males and those who live in Central and Eastern Highlands Provinces. These provinces have interprovincial highways connecting with main ports in Port Moresby, Morobe and Madang Provinces. Public facilities such as schools, markets, churches and residential areas are located alongside these highways, which carry large numbers of heavy container trucks and crowded buses. Roads are often under maintenance. These highways have no pedestrian access or guard rails to support travel. Schoolchildren and residents walk on the roads and one-lane bridges, sharing them with other transportation means. Although the PNG Government allocates a large budget to maintain transportation infrastructures, road conditions often deteriorate in a short period of time, particularly in the Highlands Region, during the rainy season. Many drivers are not adequately trained and do not comply with traffic rules. Alcohol consumption before and during travel is commonly observed among drivers. Although the police are regularly called to randomly check on vehicles, this may not be a practical or sustainable solution to effectively reduce road traffic accidents in PNG.

Assaults were the second leading COD from injuries. Domestic violence, tribal fighting and payback killing including sorcery are the major forms of assaults contributing to premature mortality from injuries in PNG. Domestic violence is common in PNG. Young female adults are more likely to die from this violence than others. About 50% of women of reproductive age (15–49 years) reported having experienced verbal abuse, and 20% reported being forced to have sex in the past 12 months. Three main underlying reasons for this include misperception of gender violence, polygamy, and the misuse of alcohol and illicit drugs.

Misperception of domestic violence is common. Around 50% of men and women perceive that it is justifiable for husbands or male sexual partners to beat or hit their wives or female sexual partners if the females went out without informing their partners. A quarter of women and men believed that it is justifiable for a man to hit or beat his wife or sexual partner if she refused to have sex with him. In some cases, women were reportedly beaten to death because they did not perform their domestic duties and other cultural obligations.

Polygamy is common in many parts of PNG. About one-fifth of men reported having additional partners aside from their wives. Married and live-in-union women reported that their husband had an additional 1.4 sexual partners. Extra marital affairs are the underlying cause of domestic violence in many cases. Disagreements in sexual acts often start between two women in a public place such as a market or bus station. The arguments can be fuelled with interference from men and other family members. If not resolved, these fights can escalate, possibly resulting in deaths.

The misuse of alcohol and illicit drugs is a trigger for domestic violence, with 70% of reported cases being associated with alcohol use prior to the violence. Marijuana use for entertainment has increased, leading to homicides in Eastern Highlands Province. Peer pressure is often the reason why young men and women get involved in the plantation, distribution and consumption of marijuana. Unprotected sex under the influence of alcohol and illicit drugs is an important factor in the spread of HIV/AIDS infection among young adults.

Tribal fights in PNG are often associated with disputes over land ownership among families, clans and villages, and can date back to several generations. Young people, including women and children, are usually victims of such fighting. The increased use of guns, especially high-powered machine guns and hand grenades, instead of traditional weapons such as bush knives and axes in the recent tribal fights, has resulted in a larger number of deaths. Tribal fights are also fuelled by political purpose, especially during national and local elections when different groups of political supporters are agitated to use violence to suppress their opponents. One case in Eastern Highlands Province in mid-2021 reported 19 deaths in the media, but the actual number of casualties could be as high as 200. Although there is no clear link between increased social instabilities and the recent outbreaks of COVID-19, it seems that increased poverty and societal stresses while the country was in lockdown could further scale up the violence in PNG.
Retribution killings are often expressed in the form of ‘sorcery’, where a sudden death takes place in the community, and family members of the deceased claim the death to be by ‘sorcery’ by a particular person, who is then murdered. PNG has a widespread belief in sorcery for a long time. In a recent sorcery-related killing in Madang, a 37-year-old man was reportedly beheaded to death. The victim was suspected of practising sorcery that led to the deaths of a child and two men. Another young man was sentenced to 18 years of imprisonment in 2021 for murdering a woman after suspecting her of being a sorcerer.39 Harsh sentences are imposed for sorcery-related violence, but killings related to sorcery have not decreased in the country.

In this study, the proportion of injury-attributed mortality was lower than those reported by the Medical Certification Cause of Death (MCCD) study.40 The difference could be because we collected mortality data from the communities while MCCD data were from tertiary hospitals. Surveillance data showed that injuries associated with road traffic accidents accounted for 4% of total case loads presenting at primary health facilities from 2015 to 2017, but this increased to 6% from 2018 to 2020.13 14

Our study showed the highest proportions of deaths from injuries among school-aged children, adolescents and young adults, reconfirming the importance of prevention of injuries as an emerging public health issue in PNG. The misuse of alcohol and illicit drugs in areas where rapid urbanisation is occurring is the root cause of the increased mortalities from injuries. The uncontrolled operation of nightclubs and bars has increased the risks of road traffic accidents, domestic violence and tribal fighting in PNG. In most cases, mortality and morbidity associated with road traffic accidents, domestic violence and tribal fighting are avoidable through implementation of effective measures, laws and policies. The increased morbidity and mortality from injuries require

| Table 2 | Adjusted ORs of mortalities from injuries among surveillance population by sociodemographic characteristics of the deceased, PNGIMR’s CHESS, 2018–2020 |
|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| Socioeconomic determinant | Category | N | % | OR* | Lower bound | Upper bound | P value |
|-----------------|-----------------|---|---|-----|-------------|-------------|---------|
| Age group | 0–4 | 39 | 5.9 | 0.283 | 0.033 | 2.391 | 0.246 |
| | 5–14 | 20 | 3.0 | 3.951 | 1.093 | 14.279 | 0.036 |
| | 15–24 | 45 | 6.8 | 5.893 | 2.184 | 15.900 | 0.000 |
| | 25–34 | 64 | 9.6 | 2.648 | 0.994 | 7.056 | 0.051 |
| | 35–44 | 62 | 9.3 | 1.800 | 0.649 | 4.992 | 0.259 |
| | 45–54 | 115 | 17.3 | 1.139 | 0.436 | 2.976 | 0.790 |
| | 55–64 | 131 | 19.7 | 1.200 | 0.435 | 2.887 | 0.814 |
| | 65–74 | 102 | 15.3 | 0.986 | 0.356 | 2.729 | 0.978 |
| | 75+ | 87 | 13.1 | Ref | 64.0 | 2.000 | 1.192 | 3.556 | 0.099 |
| | Sex | Male | 387 | 58.2 | Ref | 2.000 | 1.192 | 3.556 | 0.099 |
| | Female | 278 | 41.8 | Ref | 64.0 | 2.000 | 1.192 | 3.556 | 0.099 |
| | Sector | Urban | 226 | 34.0 | Ref | 64.0 | 2.000 | 1.192 | 3.556 | 0.099 |
| | Rural | 439 | 66.0 | Ref | 64.0 | 2.000 | 1.192 | 3.556 | 0.099 |
| | Province† | POM | 30 | 4.5 | Ref | 64.0 | 2.000 | 1.192 | 3.556 | 0.099 |
| | Central | 167 | 25.1 | Ref | 64.0 | 2.000 | 1.192 | 3.556 | 0.099 |
| | EHP | 277 | 41.7 | Ref | 64.0 | 2.000 | 1.192 | 3.556 | 0.099 |
| | Madang | 75 | 11.3 | Ref | 64.0 | 2.000 | 1.192 | 3.556 | 0.099 |
| | ENB | 116 | 17.4 | Ref | 64.0 | 2.000 | 1.192 | 3.556 | 0.099 |
| | Household wealth | Poorest | 135 | 20.3 | Ref | 64.0 | 2.000 | 1.192 | 3.556 | 0.099 |
| | Poor | 135 | 20.3 | Ref | 64.0 | 2.000 | 1.192 | 3.556 | 0.099 |
| | Middle | 130 | 19.5 | Ref | 64.0 | 2.000 | 1.192 | 3.556 | 0.099 |
| | Rich | 130 | 19.5 | Ref | 64.0 | 2.000 | 1.192 | 3.556 | 0.099 |
| | Richest | 135 | 20.3 | Ref | 64.0 | 2.000 | 1.192 | 3.556 | 0.099 |
| | Valid | 665 | 100.0 | 64.0 | 2.000 | 1.192 | 3.556 | 0.099 |
| | Missing | 261 | Ref | 64.0 | 2.000 | 1.192 | 3.556 | 0.099 |
| | Total | 926 | Ref | 64.0 | 2.000 | 1.192 | 3.556 | 0.099 |

*Unadjusted and adjusted ORs are similar. Hence, only adjusted ORs are presented in this table.
†Household SES data from ESP were not available as the site was established in early 2019.
CHESS, Comprehensive Health and Epidemiological Surveillance System; EHP, Eastern Highlands Province; ENB, East New Britain; ESP, East Sepik Province; PNGIMR, Papua New Guinea Institute of Medical Research; POM, Port Moresby; SES, socioeconomic status.
a policy and intervention response to reduce deaths from these causes.\textsuperscript{41} Education and public awareness of tribal fighting, retribution killings and sorcery play an important role in such interventions. Universal access to healthcare services at the primary health level is crucial to effectively deliver injury prevention interventions.\textsuperscript{42}

Limitations
The mortality data used in this study were collected from the populations who live within the catchment areas of CHESS. The data only represent the surveillance population. The number of deaths was relatively small in some subpopulations, that is, children aged 0–4 years and the elderly aged 75+ years. However, combining some subpopulations to obtain a larger number of observations could lead to misinterpretation of the results because the COD varies across subpopulations. The number of VA interviews was also limited in POM and Madang, where new surveillance sites were more recently established. The mortality information of the deceased provided by close relatives via VA interviews could be incomplete and biased due to reliance on the recall process. The linkage between mortality data and household socioeconomic data was another challenge due to the high internal migration rates reported in these surveillance sites, that is, among 926 deceased who were assigned specific CODs, only 665 death records (72\%) were successfully linked with household socioeconomic data and generated individual wealth indices. As such, the research findings should be interpreted with some caution.

CONCLUSIONS
PNG is undergoing an epidemiological transition with increased mortality from injuries, but little is known about prevalence and specific CODs from injuries or sociodemographic factors associated with injury-attributed mortalities. This paper is the first known study in PNG that used the InterVA-5 program to determine the variation of injury mortality by sociodemographic characteristics of the deceased, using mortality surveillance data collected from the communities. Injuries and external causes were responsible for 13\% of the total deaths and road traffic accidents were the leading COD from injuries, accounting for 43\% of injury-attributed deaths.

MLR models were used to explore sociodemographic factors associated with injury mortality at the population level. Young adults aged 15–24 years, particularly those who lived in urban areas, were most at risk of dying from injuries. Road traffic accident was the leading COD in males while assault was the leading COD among females. Public health policies and interventions targeting young population and urban residents are needed to reduce premature mortality from injuries, particularly road traffic accidents among males and assaults among females in PNG.

Recent social changes are an important driver of the increased mortality from injuries in PNG. The increased risk of dying from road traffic accidents was likely associated with the recent socioeconomic development in PNG. Underlying the development are the poor living condition and unsafe working environment, where injury-associated risk factors are present and interact with cultural beliefs and practices, and institutional policies. We have examined these social factors and provided information to develop interventions targeting population groups to address specific CODs from injuries. This evidence can be used by the health sector to more effectively respond to the new demands of healthcare services for prevention and control of injuries in the population. The data are necessary to prioritise healthcare services and design public health interventions, especially at the primary health level to effectively prevent such deaths.

The epidemiological diversity in CODs from injuries calls for an improvement in availability and utilisation of surveillance data across the geographical regions to better target policies and interventions. Coercive public health measures on road safety, management and control of alcohol and illicit drugs are urgently needed. More important is ensuring such policies are effectively implemented to prevent premature mortality. Prevention initiatives should be focused and tailored to address specific CODs from injuries, as well as the risk factors relevant to local contexts. Further studies on injuries in PNG are needed and require a systematic approach to assess both socioeconomic determinants and factors within the health systems.

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Contributors BNP designed the CHESS, conceptualised the paper, analysed and interpreted the data, and drafted, revised, finalised and submitted the manuscript. BNP had full responsibility for the work and the conduct of the study, had access to the data, and controlled the decision to publish. SM, LK, VDS, NA and RJ supervised the fieldwork, collected and analysed the data, and provided inputs for the manuscript. TO provided review and feedback, and edited the manuscript. WP provided oversight to PNGIMR and approved submission of the manuscript.

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Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Next of kin consent obtained.

Ethics approval This study involves human participants. The CHESS was granted ethics approvals from Institutional Review Board of PNG Institute of Medical Research (IRB approval no. 18.05) and the Medical Research Advisory Committee of Papua New Guinea (MRAC approval no. 18.06). These approvals covered all the data components under the CHESS, including the mortality data which were used in this manuscript. Informed consent was sought from self-identified close relatives of the deceased. They were informed about their right to withdraw from the study at any stage.

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