ETHNIC-SPECIFIC MORTALITY PATTERNS IN MALAYSIAN PUBLIC HOSPITALS: UNVEILING DISPARITIES AND OPPORTUNITIES FOR INTERVENTION

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Abstract. Mortality rates vary among Malaysian subpopulations, and socioeconomic variables are thought to play a major role in these variations. However, since these factors are intimately linked to the population's ethnic makeup, understanding the variation in mortality requires an examination of the causes of death across various ethnic groups. Using population-based data from the national health data warehouse, this study analyzed ethnic-specific causes of mortality in 135 public hospitals in Malaysia, stratified by selected demographics. Utilizing an innovative visual summary, we present a general mortality pattern across the study period, highlighting the causes of death stratified by age, gender and ethnicity. Out of 10,029,045 inpatients, 2.3% died. The main causes of in-hospital deaths were infection-related, followed by cardiovascular diseases, including stroke and its sequelae. While causes of death showed ethnic variations, but with advancing age there was a convergence. By emphasizing the different ways that mortality impacts the various Malaysian ethnic groups, this study highlights the need for targeted public health interventions. Specifically, efforts should focus on reducing cardiovascular disease mortality among Bumiputeras and Indian-Malaysians, and cancer-related mortality among Chinese-Malaysians.

Keywords: diagnosis of death, ethnicity, hospitalization, in-hospital mortality, Malaysian demographics

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INTRODUCTION

Malaysia is a federation of thirteen states and three territories with a population of more than 32 million people (Department of Statistics Malaysia, 2021). Its population comprises three major ethnic groups: Bumiputera, Chinese-Malaysian (Chinese), and Indian-Malaysian (Indian). Bumiputeras constitute around 70% of Malaysia's population, including Malays, Orang Asli of Peninsular Malaysia and indigenous people of Sabah and Sarawak. Among Bumiputera, Malays constitute the predominant group, making up the largest portion of the population (60%), while other Bumiputera groups account for about 11-12% of the population. The Chinese community represents 20% of the population and the Indian community comprises approximately 7% (Department of Statistics Malaysia, 2021). Since gaining independence in 1957, Malaysia has seen significant improvements in population health due to policies prioritizing universal healthcare (Merican and bin Yon, 2002). Between 1965 and 2015, life expectancy at birth for the general population increased from 62.4 to 72.5 years for males and from 64.0 to 77.4 years for females (Tey *et al*, 2016). This improvement can be attributed to a decline in mortality from infectious diseases, due to advances in the healthcare systems.

However, the rate of life expectancy improvement has decreased in recent years (Malaysian Healthcare Performance Unit, 2020). This slowdown has been attributed to the rising prevalence of non-communicable diseases (NCDs), which has outpaced advancements in the healthcare system (IPH, 2011; IPH, 2015). Notably, between 2006 and 2015, the percent adults diagnosed with diabetes mellitus in Malaysia increased by 66% (Letchuman *et al*, 2010; Ismail *et al*, 2018). The rise in NCDs is projected to result in an increased incidence of cardiovascular disease (CVD) deaths (Mathers and Loncar, 2006). For instance, between 2009 and 2010, individuals with CVD constitute approximately 6.91% of all hospital admissions, accounting for 24.5% of deaths in Malaysian government hospitals (Lu and Nordin, 2013). In addition to CVD, cancer also remains a public health concern. Comparing 2007-2011 and 2012-2016, the cancer incidence

rate among females increases by 2.3 per 100,000 population but that of males decreases by 0.8 per 100,000 (National Cancer Registry Department Ministry of Health, 2019).

Nevertheless, communicable diseases continue to be a major health challenge in Malaysia. Sepsis and pneumonia have consistently ranked among the top symptoms in public hospitals, contributing to approximately one-third of all hospital deaths between 2012 and 2016 (Ministry of Health Malaysia, 2017). In 2016, Malaysia reported 26,168 tuberculosis (TB) cases - an 8% increase from 24,220 cases in the previous year, with an overall 35% rise from 19,337 cases in 2010 (Kaur *et al*, 2020). On the other hand, the estimated human immunodeficiency virus (HIV) infection incidence rate per 1,000 uninfected population decreased from 0.30 to 0.19 between 1990 and 2021, but HIV-related deaths have remained steady at about 5 per 100,000 since 2017 (Ministry of Health Malaysia, 2022).

The discordance between the advancement in Malaysia's healthcare system and the growing disease burden was identified as a significant factor limiting further gain in life expectancy (Atun *et al*, 2016). However, from a different perspective, this stagnation could also be attributed to differences in improvement rates among subpopulations. Gaps in life expectancy among various sociocultural groups have been observed and continue to widen over time (Tey *et al*, 2016). For example, the average life expectancy of a Chinese woman is reportedly around 80 years, while that of an average Indian man is expected to be about 60 years (Ministry of Health Malaysia, 2017).

The variation in life expectancy among Malaysia's ethnic groups has been linked to socioeconomic inequalities, notably disparities in income (Chan and Devi, 2015; Saari *et al*, 2015; Mariapun *et al*, 2016). For example, in 2016, the average monthly household income of the Chinese population is 1.4 times greater than that of the Bumiputera population (Balqis-Ali *et al*, 2021). Bumiputeras, particularly Malays, have been the focus of affirmative action policies aimed at reducing economic disparities and promoting equity, given the historical economic challenges of this ethnic group compared to other

groups. While these efforts have positively impacted their status, income disparities still persist within the Malay community, with rural Malays having a lower income compared to those in urban areas (Shamsul, 1997). The Chinese community in Malaysia has a strong presence in commerce and industry. Historically, they have faced fewer barriers to education and economic participation, resulting in higher average income and a strong presence in urban areas (Heng, 1997). The Indian community exhibits more socioeconomic diversity, with some members, particularly professionals, achieving high socioeconomic status, but a considerable portion, especially those descended from plantation workers, continue to face economic challenges (Fee, 2002).

Economic factors may contribute to health disparities among the ethnic groups, but there are also notable differences in intrinsic morbidity and mortality risks. For instance, metabolic syndrome significantly increases the risk of mortality among Malays, a pattern not observed in other ethnic groups (Chee Cheong *et al*, 2021). A nationwide analysis of colorectal cancer from 2012 to 2016 shows a higher incidence rate among the Chinese ethnic group compared to that of the Malay: 15.2 and 19.6 per 100,000 Chinese females and males respectively compared to 9.4 and 12.2 per 100,000 Malay females and males respectively (National Cancer Registry Department Ministry of Health, 2019). Furthermore, cancer stage-specific survival rates differed significantly among the ethnic groups: in stage III colorectal cancer, Indian patients have a 5-year survival rate of 10.1% compared to 13.0% for Malay patients, and in stage IV, Chinese patients have a 5-year survival rate of 2.1% compared to 6.1% for Malay patients (Muhamad *et al*, 2023).

Analyzing mortality data by ethnicity is expected to enhance our understanding of ethnic differences in mortality diagnoses and identify bottlenecks in improving life expectancy. Previous studies on this subject have produced findings with limited generalizability (Hanis *et al*, 2019; Ly *et al*, 2021). Therefore, this study aimed to leverage Malaysia's extensive public hospital administrative database to delineate the country's top ten diagnoses of mortality according to selected demographics. Administrative

hospital data have been described as a cost-effective resource for significant improvement in health policy (Coory *et al*, 2002; Olver, 2014). Given Malaysia's multiethnic population, focusing on ethnic-based data will help guide the design and implementation of a more improved and inclusive national health agenda.

MATERIALS AND METHODS

Data source and collection

A descriptive cross-sectional analysis was performed using the Malaysian Health Data Warehouse (MyHDW) (https://myhdw.moh.gov.my) patient discharge data from January 2012 to December 2016. Details regarding data collection methods, variable lists, and data reliability of the MyHDW database have been previously described (Mark and Ahmad, 2017). One hundred thirty-five public hospital data points were used, based on data availability and the bulk of healthcare services provided by the public sector (Ministry of Health Malaysia, 2017). Data access was provided through an authorized login following ethical clearance for the study protocol by the National Medical Research and Ethics Committee of the Ministry of Health (Approval no. KKM/NIHSEC/P20-505(7)).

The inclusion criterion was all inpatients one year or older of age, with a hospital stay of ≤365.25 days. The age range and duration were chosen to focus on conditions more likely to benefit from medical intervention, allowing exclusion of cases of death in very young patients or palliative care. Mortality cases with diagnosis, which were unlikely to be the cause of death, were excluded based on the World Health Organization guidelines (WHO, 2011) to minimize errors in death documentation that could bias the results. Out of 10,029,045 records initially considered, 87.8% met the inclusion criteria (Fig 1). Diagnoses and causes of death were assigned ICD-10 codes following the 10th revision of World Health Organization international statistical classification of diseases and related health problems (WHO, 2010) and categorized into 142 mutually exclusive Statistics Hospital Mortality Index (SHMI) (Pluta *et al*, 2018). Accredited ICD-10 personnel performed the coding, adhering to the WHO

classification referred to above to ensure consistency and reliability. The initial dataset contained no missing data of the variables analyzed.

Data analysis

Ethnicity is defined according to that of the Department of Statistics, Malaysia (DOSM) (Department of Statistics Malaysia, 2024), while other variables are defined according to the Malaysian Health Data Dictionary (MyHDD) (Ministry of Health Malaysia, 2013). There were 24 sociodemographic subgroups considered in the analysis, which were derived from combinations of three patient characteristics, namely, gender, ethnicity (Bumiputera, Chinese or Indian) and age groups (1-18, 19-30, 31-60, and above 60 years of age).

To obtain a list of the top ten leading causes of death during 2012-2016, proportionate mortality was first calculated for each year based on the following formula:

$$\textit{Proportionate}\ \text{mortality} = \frac{\text{Deaths with a particular diagnosis in one year}}{\text{All deaths with diagnosis in the same year}} \times 100$$

The categories of causes were then ranked according to the proportionate mortality in descending order. Causes of death in the cumulative proportion of ≥80 % constitute the "top 80%" group. The 80% cut-off value was heuristic, representing the majority of cases, and utilized to exclude rare occurrences, thereby including the most prevalent and impactful cases while minimizing the influence of outliers. The diagnoses of mortality listed in the top 80% were re-ranked from the most to the least common according to the following criteria: diagnoses for most years, followed by diagnoses in recent years and lastly diagnoses having the highest case fatality rate.

Statistical analysis

The data distribution was examined using an available case analysis. Data visualization and analysis were performed via R version 4.2.2 (https://cran.r-project.org/bin/windows/base/old/). Analysis was completed within one month of data acquisition.

RESULTS

From 2012 to 2016, 2.38-2.70% of inpatients (n = 222,131) (Fig 1) died annually, of whom 57.0% were males. The mean (± SD) age at admission of the mortality cases was 60.0 (±17.6) and 62.6 (±17.8) years for male and female patients, respectively. The ethnic distribution of the mortality cases was Bumiputera (66.0%), Chinese (23.1%) and Indian (9.1%), which corresponded to the ethnic distribution of the national population (Department of Statistics Malaysia, 2017).

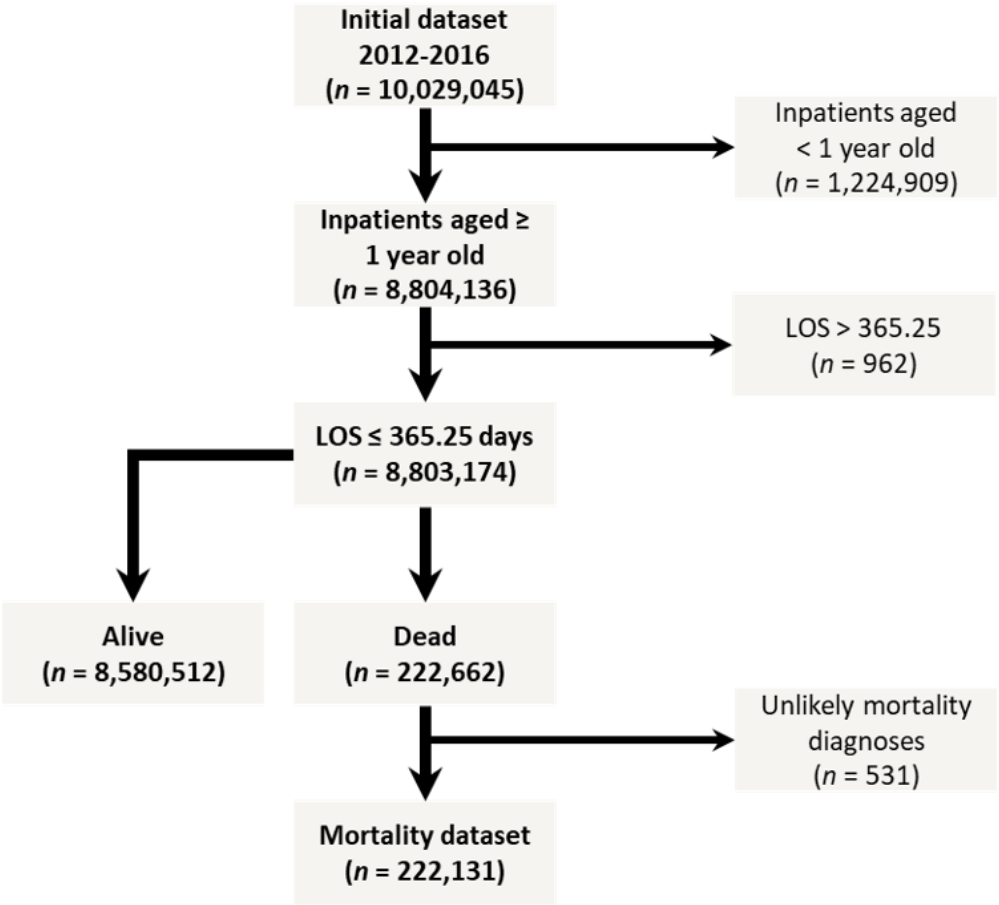

Fig 1 - Diagram illustrating quantity of remaining data after applying each exclusion criterion

LOS: length of stay

The age distribution at mortality was further analyzed according to ethnic group and year of study (from 2012 to 2016) for each gender (Table 1). Stratified two-way ANOVA was performed to determine the statistical significance of the age distribution at mortality among ethnic groups across study years for each gender. The interaction effect (ethnic group at the year of mortality) was nonsignificant for both genders (male: F = 0.712; *p*-value = 0.681; female: F = 1.89; *p*-value = 0.057). For males, the main effects analysis revealed a statistically significant association between ethnic group and age at mortality (F = 2250.17; df = 2; *p*-value <0.001). A subsequent post hoc Tukey test confirmed significant differences among the ethnic groups in all pairwise comparisons. A similar association was observed for females (F = 2360.66; df = 2; *p*-value <0.001). The post hoc Tukey test further verified significant differences among the ethnic groups in all pairwise comparisons.

Among children and adolescents (1-18 years of age), the most commonly reported diagnoses of in-hospital deaths were infection (septicemia and pneumonia), leukemia, acute cerebrovascular diseases, and congenital anomalies (Fig 2A). Acute and chronic kidney diseases were more prevalent among the Indian population, while fatal inflammatory heart conditions and cardiomyopathy were more frequently observed among the Bumiputera. Conditions associated with "allergic reactions, aftercare and screening, and R codes", encompassing general symptoms, signs, and abnormal clinical and laboratory findings were also reported as the causes of mortality.

Among young adults (19-30 years of age), the most common diagnoses of in-hospital deaths were infections, leukemia and acute cerebrovascular diseases (Fig 2B). Infections of the central nervous system and inflammatory heart conditions, including cardiomyopathy, were exclusively frequent among the Bumiputera. Ethnic-gender disparities were evident for tuberculosis and HIV infections, which were common in both genders for the Bumiputeras but only among males for the Chinese group. Additionally, common causes of mortality among Bumiputera and Chinese females included complications from rheumatoid

Table 1

Age of mortality cases (n = 222,131) in Malaysian public hospitals according to ethnicity and gender, 2012-2016

Demographic	Age of in-hospital mortality cases (years, mean ± SD)				
	2012	2013	2014	2015	2016
Male*					
Bumiputera	57.0 ± 19.0	58.1 ± 18.5	58.6 ± 18.0	58.7 ± 17.9	59.0 ± 17.6
Chinese	64.5 ± 15.5	65.5 ± 15.3	65.9 ± 15.2	66.3 ± 15.1	66.6 ± 15.0
Indian	55.2 ± 16.9	57.4 ± 16.5	57.0 ± 16.5	57.3 ± 16.3	57.9 ± 16.2
Female**					
Bumiputera	58.5 ± 19.1	60.4 ± 18.1	60.4 ± 17.8	60.9 ± 17.5	61.0 ± 17.5
Chinese	68.3 ± 16.6	69.5 ± 15.6	69.9 ± 15.6	69.7 ± 15.7	70.8 ± 14.8
Indian	59.2 ± 18.3	61.7 ± 16.2	62.2 ± 16.2	62.7 ± 16.1	63.2 ± 16.2

*Main effect (among ethnicity) is significant: F = 2250.17, df = 2, p-value <0.001

**Main effect (among ethnicity) is significant: F = 2360.66, df = 2, p-value <0.001

A

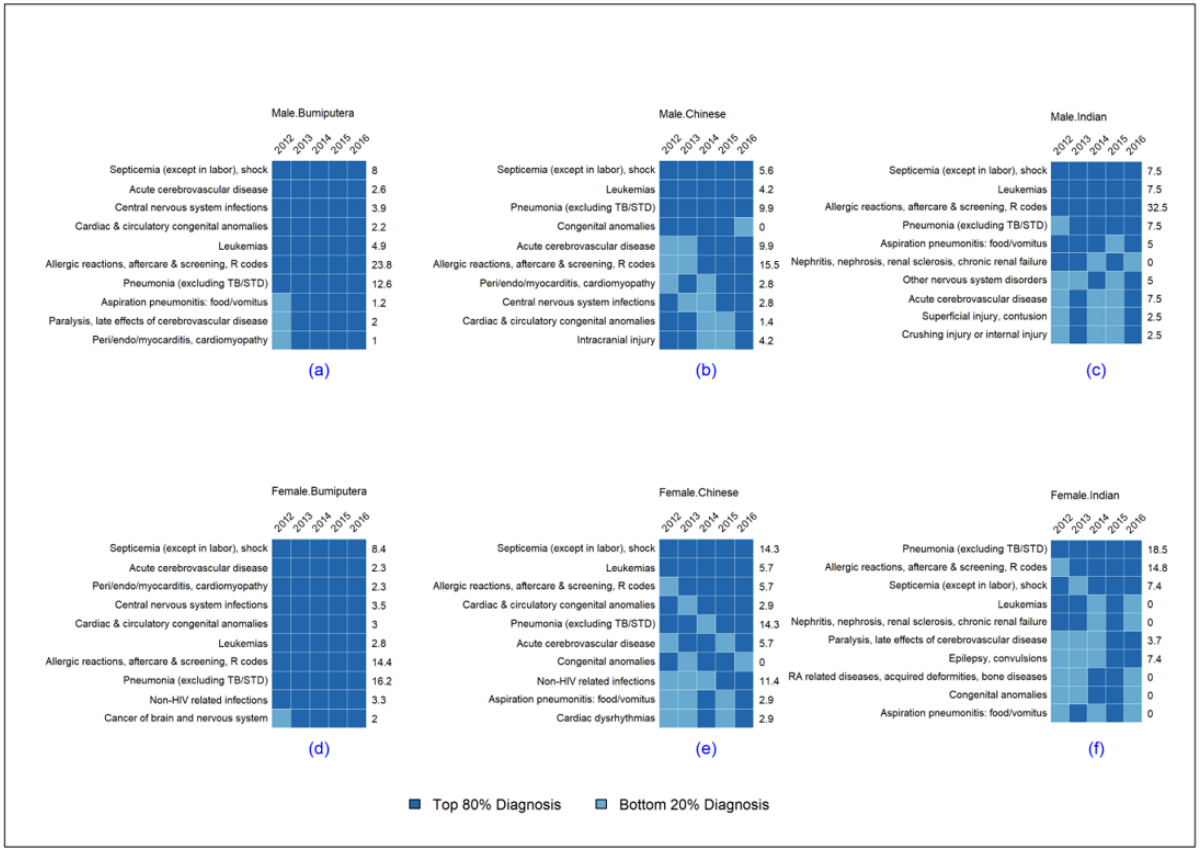

Fig 2A - Heat map of top 10 causes of mortality among children and adolescents in Malaysian public hospitals according to ethnicity and gender, 2012-2016

Note: Children and adolescents are those aged 1-18 years. Numbers on right border of the plot indicate proportionate mortality.

COPD: chronic obstructive pulmonary diseases; HIV: human immunodeficiency virus; RA: rheumatoid arthritis; STD: sexually transmitted diseases; TB: tuberculosis

B

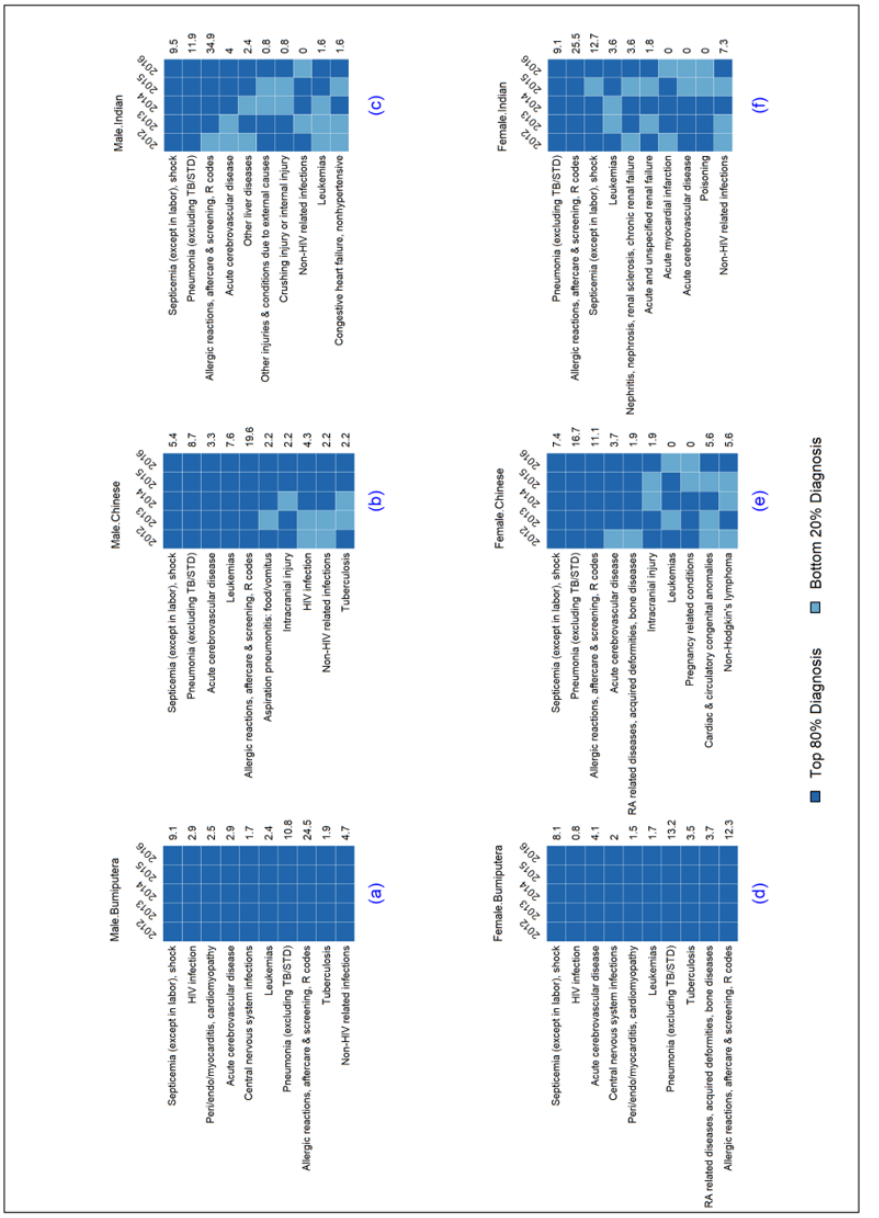

Fig 2B - Heat map of top 10 causes of mortality among young adults in Malaysian public hospitals according to ethnicity and gender, 2012-2016

Note: Young adults are those aged 19-30 years. Numbers on right border of the plot indicate proportionate mortality.

COPD: chronic obstructive pulmonary diseases; HIV: human immunodeficiency virus; RA: rheumatoid arthritis; STD: sexually transmitted diseases; TB: tuberculosis

arthritis-related illnesses and bone disorders, which were not common among female Indians.

Among adults (31-60 years of age), the predominant diagnoses of in-hospital death were infections, aspiration pneumonitis, nonalcoholic liver disease, and acute cerebrovascular disease (Fig 2C). HIV infection was notably prevalent among the Bumiputera group, while tuberculosis-related deaths were more common among Indians and only among males of the Chinese group. Notably, among adults admitted to hospitals, cancer was the highest contributor to mortality. In 2016, breast cancer accounted for approximately 4.4% to 11% of in-hospital deaths among females of Indian and Chinese descent. Conversely, bronchus and lung cancer accounted for approximately 2.2% to 4.0% of in-hospital deaths among Bumiputera and Chinese males. Cancer-related deaths were more prevalent among the Chinese group than the other two ethnic groups. For Chinese females, the primary causes of mortality included breast cancer (10.7%), lung cancer (3.6%), cancer of the head and neck (1.5%), and uterine cancer (0.8%). Among Chinese males, lung cancer (3.5%), head and neck cancer (3.3%), liver and intrahepatic bile duct cancer (2.7%), and leukemia (1.1%) were the most common diagnoses of death.

Among the elderly (≥61 years of age), ethnicity-specific diagnoses of death were less differentiated (Fig 2D). The predominant factors contributing to mortality were infections, acute cerebrovascular diseases and cardiovascular diseases, including acute myocardial infarction and other coronary artery diseases. Lung cancer-related deaths were exclusively diagnosed among Bumiputera and Chinese groups, while congestive heart failure was exclusive to the Indian group. Notably, deaths arising from liver diseases unrelated to alcohol consumption consistently occurred among males, while breast cancer-related fatalities were notably more common among elderly Chinese females.

DISCUSSION

This study examined the distribution of in-hospital mortality diagnoses, stratified by age group, gender and ethnicity, with specific emphasis on the top ten contributors to death. Over the

C

Fig 2C - Heat map of top 10 causes of mortality among adults in Malaysian public hospitals according to ethnicity and gender, 2012-2016

Note: Adults are those aged 31-60 years. Numbers on right border of the plot indicate proportionate mortality.

COPD: chronic obstructive pulmonary diseases; HIV: human immunodeficiency virus; RA: rheumatoid arthritis; STD: sexually transmitted diseases; TB: tuberculosis

Fig 2D - Heat map of top 10 causes of mortality among elderly in Malaysian public hospitals according to ethnicity and gender, 2012-2016

Note: Elderly are those aged >60 years. Numbers on right border of the plot indicate proportionate mortality.

COPD: chronic obstructive pulmonary diseases; HIV: human immunodeficiency virus; RA: rheumatoid arthritis; STD: sexually transmitted diseases; TB: tuberculosis

five-year study period (2012-2016), pneumonia, septicemia, and acute cerebrovascular diseases emerged as the predominant causes of death across all demographic subgroups within public hospitals (Table 2). The prominence of infectious diseases among hospitalized patients, coupled with the increasing prevalence of cerebrovascular diseases, is a cause for concern (Omar *et al*, 2019). Insights gleaned from the National Health and Morbidity Survey (NHMS), an annual survey conducted to determine the health status of the Malaysian population, revealed that approximately one-third of Malaysians were identified as obese (IPH, 2011; IPH, 2015). Additionally, half of those found to have elevated blood sugar levels had undiagnosed diabetes (IPH, 2011; IPH, 2015). These findings underscore the potential heightened vulnerability of patients with chronic diseases to infectious agents.

An interesting observation is the preponderance of tuberculosis as the cause of death among hospitalized Malaysians. The prevalence of tuberculosis remains high in Malaysia, especially in rural areas (Bujang *et al*, 2017; Mohidem *et al*, 2018). Further analysis of the country's rural/urban ethnic composition reveals that the Chinese and Indian communities are predominantly urban dwellers, while rural regions are primarily inhabited by the Bumiputeras (Soomro and Memon, 2014). This disparity in residence location may contribute to the observed higher mortality from tuberculosis among the Bumiputera ethnic group, consistent with findings from other local studies (Ismail and Bulgiba, 2013; Mohd Shariff *et al*, 2016). Confounders of tuberculosis death have been noted to include lack of access to healthcare, poor adherence to the treatment regimen, environmental conditions, poverty, low educational attainment, and other sociobehavioural characteristics closely tied to ethnicity and locality (Ismail and Bulgiba, 2013; Mohd Shariff *et al*, 2016).

The results of the study also corroborated previous epidemiological research linking the prevalence of cancer diagnoses with the Chinese population. According to the Malaysian Cancer Registry Report 2012-2016, the Chinese population has the highest incidences of colorectal, lung and nasopharyngeal cancer (NPC), the

Table 2

Summary of common diagnoses of death (top three highest case fatalities) according to ethnicity and gender in Malaysian public hospitals, 2012-2016

Age group	Ethnicity					
	Bumiputera		Chinese		Indian	
	Male	Female	Male	Female	Male	Female
1-18 years	• Septicemia (except in labor), shock • Acute cerebrovascular disease • Central nervous system infections	• Septicemia (except in labor), shock • Acute cerebrovascular diseases • Peri/endo/myocarditis, cardiomyopathy	• Septicemia (except in labor), shock • Leukaemia • Pneumonia (excluding TB, STD)	• Septicemia (except in labor), shock • Leukaemia • Cardiac and circulatory congenital anomalies	• Septicemia (except in labor), shock • Leukaemia • Pneumonia (excluding TB, STD)	• Pneumonia (excluding TB, STD) • Septicemia (except in labor), shock • Leukaemia
19-30 years	• Septicemia (except in labor), shock • HIV infection • Peri/endo/myocarditis, cardiomyopathy	• Septicemia (except in labor), shock • HIV infection • Acute cerebrovascular disease	• Septicemia (except in labor), shock • Pneumonia (excluding TB, STD) • Acute cerebrovascular disease	• Septicemia (except in labor), shock • Pneumonia (excluding TB, STD) • Acute cerebrovascular disease	• Septicemia (except in labor), shock • Pneumonia (excluding TB, STD) • Acute cerebrovascular disease	• Pneumonia (excluding TB, STD) • Septicemia (except in labor), shock • Leukaemia

Table 2 (cont)

Age group	Ethnicity					
	Bumiputera		Chinese		Indian	
	Male	Female	Male	Female	Male	Female
31-60 years	•Septicemia (except in labor), shock •Aspiration pneumonitis: food/ vomitus •Cancer of liver and intrahepatic bile duct	•Aspiration pneumonitis: food/ vomitus •Septicemia (except in labor), shock •HIV infection	•Septicemia (except in labor), shock •Aspiration pneumonitis: food/ vomitus •Cancer of liver and intrahepatic bile duct	•Septicemia (except in labor), shock •Aspiration pneumonitis: food/ vomitus •Cancer of bronchus, lung	•Aspiration pneumonitis: food/ vomitus •Septicemia (except in labor), shock •Other liver diseases	•Aspiration pneumonitis: food/ vomitus •Septicemia (except in labor), shock •Other liver diseases
>60 years	•Septicemia (except in labor), shock •Aspiration pneumonitis: food/ vomitus •Cancer of bronchus, lung	•Septicemia (except in labor), shock •Aspiration pneumonitis: food/ vomitus •Cancer of bronchus, lung	•Septicemia (except in labor), shock •Aspiration pneumonitis: food/ vomitus •Cancer of bronchus, lung	•Septicemia (except in labor), shock •Aspiration pneumonitis: food/ vomitus •Cancer of bronchus, lung	•Septicemia (except in labor), shock •Aspiration pneumonitis: food/ vomitus •Other liver diseases	•Septicemia (except in labor), shock •Aspiration pneumonitis: food/ vomitus • Acute myocardial infarction

HIV: human immunodeficiency virus; STD: sexual transmitted diseases; TB: tuberculosis

top three cancers among Malaysian males, and the highest incidences of breast, colorectal and cervical cancer, the top three cancers among Malaysian females (National Cancer Registry Department Ministry of Health, 2019). The variation in cancer prevalence among different ethnicities may stem from genomic diversity arising from different evolutionary forces. However, further research is necessary to establish a definitive connection between genomic diversity and ethnicity (Tan *et al*, 2016).

A shift in the age distribution of mortality toward the higher age group was observed across all three ethnic groups, which parallels Malaysia's transition into an aging population. This trend also reflects Malaysia's success in achieving universal healthcare coverage and underscores the effectiveness of the healthcare system in improving life expectancy across the whole population. Nevertheless, mortality among Bumiputera and Indian groups occurred at a younger age than the Chinese population.

Considering that this study exclusively draws upon data from public hospitals, these disparities in the age of in-hospital mortality among the three ethnic groups might also reflect differences in access to private healthcare services. Malaysia's healthcare system operates on a dual public-private structure. Public hospitals provide a comprehensive range of services at subsidized rates. At the same time, the private healthcare sector caters to those who seek specialized care and are willing to pay through self-funding or insurance schemes (Jaafar *et al*, 2012). A study indicated that the Chinese population has a higher tendency to be covered by health insurance, thereby enjoying better access to private healthcare services (Cheah and Meltzer, 2020).

However, investigations into health insurance patterns in Malaysia revealed that younger individuals are more likely to be insured, while those individuals ≥50 years of age are less likely to have health insurance. This agrees with findings from other countries, where the likelihood of not having health insurance tends to increase with age (Balqis-Ali *et al*, 2021). Consequently, the higher age at mortality observed among hospitalized elderly Chinese compared to the other ethnic groups

may be partly due to their greater reliance on public healthcare, driven by lower insurance coverage in this age group.

The shift in age of mortality towards the elderly population across all ethnic groups has also been reported in other multiethnic populations. A study conducted in the United States focusing on racial and ethnic disparities in health and mortality among the elderly population revealed that even as individuals age, the disparity in mortality rates between black and non-black populations persists, with the most significant disparities occurring among those in the 65-74 years of age group, followed by convergence and crossover at the older ages (Hummer *et al*, 2004).

The observed ethnic and gender variations in mortality diagnoses highlight the need for tailored interventions and policy responses. The study identified the at-risk groups who could benefit most from proactive and preventive interventions. Policymakers and healthcare managers should focus on these groups by implementing community-based programs to improve health outcomes among these populations. Culturally appropriate and evidence-based interventions, arranged by government agencies and non-governmental organizations (NGOs), should focus on reducing the frequency of cardiovascular diseases among males in the Indian and Bumiputera communities, identified in the current study. In addition, there should be an emphasis on promoting healthier lifestyles in these populations to empower individuals to maintain lifelong good health.

Effective design and implementation of proactive and preventive care interventions will require robust evidence and sufficient resources, including financial support. Preventive care is valuable when it effectively reduces costs while improving health. Therefore, priority should be given to programs targeting high-risk populations. A systematic evaluation of these programs is essential to provide policymakers and healthcare managers with information on their effectiveness.

Further research is recommended to explore the causes of mortality and their impact on life expectancy. Such research would equip policymakers and planners with the necessary

data to allow informed decisions to improve people's health. This effort should be further supported by data providers presenting data focussed on ethnicity, gender, geographical area, income status, and education level.

While other potential confounding variables (such as lifestyle, comorbidity and health-seeking behavior) may further explain the variation in ethnic-specific mortality patterns, the use in the current study of the stratified analysis enhances the comparison among the ethnic groups. Moreover, the findings aligned with expectations from other studies (Mariapun *et al*, 2016; You *et al*, 2022), which highlight the influence of sociodemographic factors on mortality patterns among the Malaysian population. Nonetheless, further research that includes additional factors may offer insights into the same research questions but with more nuances.

It is worth noting the several limitations of the current study. Firstly, only in-hospital mortality data from public hospitals were used, which may not lead to a true representation of the specific demographics as the analysis did include patients who sought care and subsequently died in private healthcare facilities. Secondly, the analysis did not account for the actual socioeconomic status of the population as data were lacking on household income at the lowest economic unit. Thirdly, specific sub-population levels were not analyzed in greater detail, and the differences in mortality among the ethnic groups may have been underestimated due to the absence of socioeconomic data and the socioeconomic diversity within the ethnic groups.

In conclusion, the study contributed to the existing body of knowledge by showcasing the correlation among ethnic groups of sociodemographic factors and disease-specific mortality, while also casting light on the potential interactions of mortality diagnoses with age among hospitalized Malaysians. The study revealed an evident difference in mortality across Malaysia's three major ethnic groups. The study's findings further underscored the substantial burden of cancer-related deaths, which were particularly predominant in the Chinese group. These observations were

in agreement with the trend of an aging population and the mounting impact of noncommunicable disease risk factors in Malaysia. Addressing these complexities demands community-based interventions and policy responses that are both demographically targeted and culturally sensitive. By directly focusing on reducing cancer risks in the Chinese community and enhancing health risk factors among the Bumiputera and Indian communities, there exists a potential to reduce the mortality of hospitalized patients with subsequent enhancement in the health of the overall Malaysian population.

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CONFLICT OF INTEREST DISCLOSURE

The authors declare no conflict of interests.

DATA AVAILABILITY

Data used in the study are available upon request, but will be granted only when deemed necessary and appropriate.

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