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Individual-level and neighborhood-level shifts in mortality patterns among drug poisoning deaths in a high-density Asian city: a territory-wide, case-only analysis

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Background: The shifts in individual-level and neighborhood-level patterns of drug poisoning deaths in a high-density Asian city over time have been underestimated, although they provide essential information for community-based surveillance and interventions.

Methods: A case-only analysis with a 16-y, territory-wide, population-based registry in Hong Kong was applied to compare drug poisoning deaths from 2001 to 2010 with 2011 to 2016. Drug poisoning deaths, deaths from heroin and deaths from other opioids (codeine or morphine) were extracted (ICD codes: T36-T50, T40.1, T40.2). Binomial regressions were used to estimate the shifts in mortality patterns.

Results: Among 3069 drug poisoning deaths, a significant shift in mortality patterns was found despite a decreasing mortality trend in Hong Kong. Overall, drug poisoning deaths shifted towards middle-aged/young-old, widowed/divorced, economically active, white collar and non-local born. Since 2011, more deaths from heroin were in older ages and non-local born, but less were never married and economically inactive. More deaths from other opioids were middle-aged, young-old and divorced. In particular, most decedents shifted towards young-old, especially deaths from other opioids. Compared with deaths during 2001-2010, there were 3.72- and 6.50-fold more deaths from heroin and deaths from other opioids in those aged ≥60 y since 2021 (ORs: 3.72 [2.37, 5.86], 6.50 [3.97, 10.65]), respectively. Additionally, drug poisoning deaths shifted towards areas with less neighborhood deprivation (more high-education individuals and a mix of private/public housing residents), especially deaths from other opioids.

Conclusion: Misuse of registered drugs (e.g. opioid pain relievers) could be a rising trend among vulnerable subpopulations in Hong Kong other than illegal drug use (heroin). Health officials should provide more advice and support on drug information. Specifically, an improved health system with education regarding the appropriate use of registered drugs for medical treatments should be provided to mid-/high-income and local-born individuals.

Keywords: drug poisoning, high-density Asian cities, mortality patterns, opioid deaths, sociodemographic, temporal effect.

Introduction

Drug poisoning death represents a major global health burden. A global study estimated that about 86 400 deaths were caused by unintentional poisonings in 2015, including 90% of deaths from low- and middle-income countries.1,2 Despite a decreasing trend of drug poisoning deaths worldwide,1 one study found that drug overdose deaths in the USA increased by 137% since 2000, including a 200% increase in death rates involving opioids, such as opioid pain relievers and heroin.3 The variations in death trends could be due to the differences in social infrastructure and health systems in various countries.4 Individual socioeconomic status and neighborhood deprivation may affect drug poisoning deaths,5 including income,6-8 age/gender effects,9,10 employment status/occupations11-13 and cultural/racial backgrounds.14,15 These factors may lead to different practices of drug uses, both intentionally and unintentionally, among various subpopulations. A recent US study found
that counties with high heroin and ‘syndemic’ opioid mortality were more urbanized areas with less economically disadvantaged and regions with a larger proportion of professional workers, but not counties with neighborhood deprivation. Another US study found that living in a county with more greenness did not reduce drug-related health problems but increased opioid mortality.

Although sociodemographic factors may affect drug poisoning deaths, previous studies mainly focused on the association between individual socioeconomic vulnerability, neighborhood deprivation and drug poisoning deaths. Only a few studies have investigated how spatial patterns of mortality may shift over time. These studies describing spatiotemporal shifts in mortality were focused on large regions (e.g. the entire USA) across Westernized countries with significant urban/rural difference. No studies have investigated how sociodemographic factors influenced mortality shifts over time in a high-density Asian city with extensive urbanized areas and a high-rise, compact environment. This is essential, as an urbanized population is not homogenous, and urbanized areas generally have a larger mortality risk associated with drug-related mortality than rural areas, even if these areas were less economically disadvantage.

Additionally, cultural practices/racial backgrounds and other sociodemographic factors in a high-density Asian city are quite different from American/European countries. Even ‘Westernized’ megacities in Asia, such as Hong Kong and Singapore, are still predominantly Chinese and perform traditional Asian cultural practices. Thus, Asian people in high-density cities would have various intentions to use both registered/illegal drugs compared with people from cities in the Global North. For example, some American and Canadian cities have culturally identified cannabis products as drugs suitable for daily use, resulting in a high intention to consume cannabis products among several American/Canadian subpopulation groups. However, people in high-density Asian cities such as Singapore and Hong Kong have promoted cannabis products as ‘illegal and harmful’, leading to a low intention of using cannabis products among the Asian population. Cultural practices and easy access to opioid pain relievers also lead to a much higher intention of using opioids and larger drug overdosing issues in the USA than in other countries. Different intentions may also result in various shifts in mortality patterns among subgroups of deaths (e.g. deaths from heroin, deaths from other opioids). Thus, Asian cities may be involved with severe issues of health inequality, including variations of at-risk neighborhoods harboring a high percentage of vulnerable subpopulations.

When there is a change of spatial clusters over time, increasing local economic/health burdens to support these neighborhoods may also occur. Therefore, it is important to analyze both individual-level and neighborhood-level shifts in drug poisoning deaths across an Asian metropolitan city to locate at-risk areas and identify vulnerable subpopulations for health planning.

This study conducted a time-stratified, case-only analysis based on a 16-y, territory-wide, population-based registry in Hong Kong. Deaths from 2011 to 2016 were compared with individuals who died from 2001 to 2010, to examine whether patterns of drug poisoning deaths in Hong Kong shifted over time.

Data and Methods

Mortality data

Individual-level mortality data (2001–2016) were obtained from the Hong Kong Census Department. These included the following variables: (1) age, (2) gender, (3) date of death, (4) cause of death, (5) external causes (if any), (6) occupation, (7) marital status, (8) county of previous residence, (9) length of stay in Hong Kong and (10) location of residence at Tertiary Planning Unit (TPU) level. TPU is a fine-scale neighborhood unit to locate the home of each decedent. We extracted drug poisoning deaths based on the International Classification of Diseases, Tenth Revision (ICD-10): T36-T50. This includes two specific subgroups: deaths from heroin (ICD-10: T40.1) and deaths from other opioids (codeine or morphine) (ICD-10: T40.2). Deaths from heroin represented the subgroups related to illegal drug use; and deaths from other opioids represented the subgroups related to registered drug use for medical treatments.

Neighborhood deprivation

This study applied four indicators of TPU-level neighborhood deprivation: (1) proportion of residents aged >15 y with tertiary education or above (% tertiary); (2) proportion of managers, professionals and associate professionals among the working population (% professional); (3) median monthly domestic household income (median income); and (4) proportion of households living in private housing (% private households). In particular, these indicators have been used for assessing neighborhood socioeconomic status by the Hong Kong Census Department. The above information was retrieved from 2016 Population By-census data.

Statistical analysis

We applied a case-only analysis to evaluate shifts in mortality patterns since 2011. Specifically, this case-only study was an assessment regarding whether the risk of a specific cause of death was shifting towards a particular group of a specific demographic characteristic (e.g. high risk among females shifting to high risk among males), assuming a proportion of demographic characteristics have not undergone a significant change despite a natural growth of the population. The year of 2011 was used as a temporal cut-off because of the registration dates of pain-related drugs (such as oxycodone) for legal use in Hong Kong. Binomial logistic regressions were used to estimate log-linear effects caused by temporal shifts on mortality patterns.

For individual-level shifts, we assigned characteristics (1,0) as a binary response variable representing the individual-level characteristic of interest of each decedent. Time (1,0) was a binary predictive variable for date of death representing the shift in mortality patterns over time. Deaths (2011–2016) were set as ‘1’ and deaths (2001–2010) were assigned as ‘0’. This study included the following individual-level characteristics of interest for comparisons (Table 1).

To combine neighborhoods with low population density, we aggregated all small TPUs to 154 large TPUs based on the definitions provided by the Hong Kong Census Department. Illegal immigrants or transients without permanent addresses,
decendants who had lived in a marine or military camp, or deaths records missing the location of residence, were excluded. For neighborhood-level shifts, a set of binary variables retrieved from the above neighborhood indicators was assigned as the response variable to represent the neighborhood-level characteristic of interest of each decedent. These neighborhood-level characteristics of interest were subgrouped as: ≥75th percentile, 50th–75th percentile and 25th–50th percentile. All characteristics of interest were compared with subgroups of <25th percentile (Table 2). Similar to analyses for individual-level shifts, time (1,0) was assigned as a predictive variable. Age, gender, marital status, occupation, Hong Kong-born or non-Hong Kong-born were applied as covariates.

Three sets of regressions were applied to evaluate shifts in mortality patterns among (1) drug poisoning deaths, (2) deaths from heroin [ICD-10: T40.1] and (3) deaths from other opioids (codeine or morphine) [ICD-10: T40.2], separately. ORs and 95% CIs were used to evaluate the shifts in mortality patterns. R (version 4.2.0) was used to perform all analyses.

Results

Data summary

Among 649,181 deaths extracted from the mortality registry, there were 3,069 deaths caused by drug poisoning during 2001–2016. Specifically, 1,088 were deaths from heroin and 844 were deaths from other opioids (codeine or morphine). After excluding death records missing the location of residence, there were 2,785 decedents. This included 944 deaths from heroin and 751 deaths from other opioids.

Drug poisoning deaths generally decreased throughout the years (Figure 1). Deaths ranged from 173 to 275 during 2001–2011, with an average of 221.8 decedents per year (SD: 34.9). The average during 2011–2016 decreased to 141.8 deaths (SD: 34.6), with a range of 82–178.

However, subgroups showed slightly different trends. Deaths from heroin increased from 2001 to 2007. There were 127 deaths from heroin in 2007. The related deaths decreased afterwards. Overall, deaths from heroin during 2001–2007 ranged from 10 to 127, with an average of 82.9 deaths (SD: 40.3). The average during 2008–2010 was 81.7 (SD: 7.5), with a range of 73–86. The average during 2011–2016 decreased to 43.8 (SD: 20.0), with a range from 21 to 72.

The number of decedents from other opioids (codeine or morphine) decreased rapidly from 2001 to 2004, and the trend was stable from 2005 to 2010. However, the number of deaths per year slightly increased again from 2011, following the registration of several drugs for medical treatments, such as oxycodone. In total, deaths from other opioids during 2001–2004 ranged from 96 to 130, with an average of 113.3 deaths per year (SD: 15.2). Deaths from other opioids during 2005–2010 ranged from 17 to 59, with an average of 33.2 deaths (SD: 15.5). The lowest number of deaths per year occurred in 2009, with only 17 related cases. Deaths from other opioids during 2011–2016 ranged from 19 to 48, with an average of 32.0 deaths (SD: 9.6).

Individual-level mortality shifts

Despite a decrease of drug poisoning deaths throughout the years, some subgroups shifted to be more vulnerable (Table 3). Overall, drug poisoning deaths shifted to the middle-aged and young-old after 2011. There was a 2.46-fold increase in deaths for the ages ≥55 y during 2011–2016 compared with 2010–2010 (OR: 2.46 [2.06, 2.94]). The ORs decreased when we compared the mortality shifts among older age groups, and the results became insignificant for shifts among decedents aged ≥70 y. Deaths from heroin and deaths from other opioids were also sensitive to mortality shifts in age, while the age cut-offs were slightly higher. The most significant mortality shift in age was found among deaths from heroin for the ages ≥60 y (OR: 3.72 [2.37, 5.86]), and the results become insignificant for deaths aged ≥70 y. The subgroup of other opioids (codeine or morphine) were clustered in ages ≥60 y with an extremely high OR (OR: 6.50 [3.97, 10.65]), while the results become insignificant for deaths aged ≥70 y.

There were also shifts in marital status and occupation. In general, less drug poisoning deaths were among the never married from 2011 onwards. The ORs for drug poisoning deaths, deaths from heroin and deaths from other opioids were 0.73 [0.62, 0.86], 0.68 [0.51, 0.90] and 0.60 [0.43, 0.83], respectively. Among drug poisoning deaths, mortality shifted towards widowed and divorced (ORs: 1.51 [1.02, 2.25]; 1.34 [1.06, 1.68]), respectively. There were also more divorced for the deaths from other opioids beyond 2011 (OR: 1.69 [1.07, 2.66]). However, mortality patterns of the deaths from heroin did not shift towards the subgroups of widowed and divorced.

<table>
<thead>
<tr>
<th>Table 1. Individual-level characteristics of interest for comparisons</th>
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<tbody>
<tr>
<td>Individual-level characteristic of interest</td>
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<tr>
<td>Age, y</td>
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<tr>
<td>Country of previous residence</td>
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<tr>
<td>Length of stay in Hong Kong</td>
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<td>External cause of death</td>
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</table>
Table 2. Neighborhood-level characteristics of interest for comparisons

<table>
<thead>
<tr>
<th>Neighborhood-level characteristic of interest</th>
<th>Comparison groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>proportion of residents aged ≥15 y with tertiary education or above in each TPU (% tertiary)</td>
<td>&gt;75th percentile vs &lt;25th percentile</td>
</tr>
<tr>
<td>proportion of managers, professionals and associate professionals among the working population in each TPU (% professional)</td>
<td>50th–75th percentile vs &lt;25th percentile</td>
</tr>
<tr>
<td>median monthly domestic household income in each TPU (median income)</td>
<td>25th–50th percentile vs &lt;25th percentile</td>
</tr>
<tr>
<td>proportion of households living in private housing within each TPU (% private households)</td>
<td>≥75th percentile vs &lt;25th percentile</td>
</tr>
</tbody>
</table>

Figure 1. Deaths from drug poisoning deaths per year during 2001–2016. (A) Drug poisoning deaths (overall). (B) Deaths from heroin. (C) Deaths from other opioids.

Less drug poisoning deaths were among the economically inactive from 2011 onwards. The ORs for drug poisoning deaths and deaths from heroin were 0.66 [0.55, 0.80] and 0.50 [0.37, 0.68], respectively. More drug poisoning deaths were non-white collar from 2011. The OR for white collar vs others among drug poisoning deaths was 0.65 [0.42, 0.99].

Additionally, less drug poisoning deaths and deaths from heroin were local born from 2011 onwards. The ORs for drug poisoning deaths and deaths from heroin were 0.83 [0.70, 0.97] and 0.72 [0.54, 0.95], respectively. However, we did not observe a statistically difference in shifts regarding local born and non-local born among deaths from other opioids. Although it was a shift due to the origins of individuals, length of stay in Hong Kong did not have associations with mortality shifts.

Less drug poisoning deaths were from accidental poisoning by and exposure to narcotics and psychodysleptics since 2011 (OR: 0.66 [0.56, 0.78]). However, the results were not statistically significant among subgroups of deaths (deaths from heroin and deaths from other opioids). This study did not observe any shifts in mortality patterns in gender among drug poisoning deaths, deaths from heroin and deaths from other opioids.

Neighborhhood-level mortality shifts

Drug poisoning deaths have shifted towards areas with specific neighborhood characteristics (Table 4). Overall, drug poisoning deaths shifted to the neighborhoods with less deprivation from 2011 onwards.

Considering covariates, we observed that there were 1.67-fold more deaths residing in a neighborhood with % tertiary ≥75th percentile since 2011 (OR: 1.67 [1.29, 2.16]). Furthermore, results of deaths from other opioids were not significant without controlling covariates; however, after adjusting the model, the results become significant. There were 2.06-fold more deaths from other opioids residing in a neighborhood with % tertiary ≥75th percentile since 2011 (OR: 2.05 [1.18, 3.56]). This study did not observe neighborhood shifts in % tertiary among deaths from heroin.

Drug poisoning deaths also shifted to neighborhoods with a higher % professional. In particular, there were 1.69-, 1.67- and 2.69-fold more drug poisoning deaths, deaths from heroin and deaths from other opioids residing in % professional between the 50th and 75th percentile since 2011 (ORs: 1.69 [1.31, 2.19], 1.67 [1.02, 2.74], 2.69 [1.55, 4.68]), respectively. Additionally, drug poisoning deaths and deaths from other opioids...
significantly shifted to neighborhoods with % professional higher than 50th percentile, but deaths from heroin only shifted to neighborhoods with % professional between 50th and 75th percentile.

Drug poisoning deaths were clustered in neighborhoods with a high household income. There were 1.45-fold more deaths in neighborhoods with a median income ≥75th percentile since 2011 (OR: 1.45 [1.13, 1.86]). However, deaths from heroin only significantly shifted towards neighborhoods with a median income between the 25th and 50th percentile (adjusted OR: 1.76 [1.08, 2.86]). We did not observe any significant shift in neighborhood-level household income among deaths from other opioids.

Additionally, drug poisoning deaths shifted to neighborhoods with mixed populations. While the results were insignificant for % private households ≥75th percentile, there were 1.50- and 1.46-fold more deaths in neighborhoods with % private households (50th–75th percentile) and % private households (25th–50th percentile). A significant neighborhood shift among deaths from other opioids was also observed. There were 2.44-fold more deaths from opioids in neighborhoods with % private households between the 50th and 75th percentile (OR: 2.44 [1.43, 4.15]).

**Discussion**

This study evaluated the individual-level and neighborhood-level shifts in mortality patterns among drug poisoning deaths in Hong Kong. The results showed mortality shifts in age, marital status, occupation, country of previous residence and external cause of deaths throughout the years. In particular, drug poisoning deaths had the most significant shift in age. Compared with deaths from 2001 through 2010, there were 2.46-fold more drug poisoning deaths in those aged ≥55 y and 3.72- and 6.50-fold more deaths from heroin and deaths from other opioids (codeine or morphine), respectively, who were aged ≥60 y during 2011–2016. Furthermore, drug poisoning deaths have been clustered in areas with less neighborhood deprivation. The most significant neighborhood shifts were found among deaths from other opioids. These decedents shifted to neighborhoods with % tertiary ≥75th percentile, % professional between the 50th and 75th percentile, % professional ≥75th percentile and % private households between the 50th and 75th percentile (adjusted ORs: 2.05 [1.18, 3.56], 2.69 [1.55, 4.68], 1.84 [1.05, 3.22] and 2.44 [1.43, 4.15], respectively). However, we only observed shifts in deaths from heroin towards neighborhoods with % professional between the 50th and 75th percentile and median income between the 25th
Table 4. Shift in neighborhood deprivation among drug poisoning deaths. ORs for all regressions are reported with 95% CIs. Bold text indicates significant results.

<table>
<thead>
<tr>
<th>Neighborhood level characteristic of interest</th>
<th>OR (95% CI)</th>
<th>Adjusted OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median income (higher vs. lower)</td>
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<td></td>
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<tr>
<td>Professional</td>
<td></td>
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<tr>
<td>&gt;= 75th percentile vs. &lt; 75th percentile</td>
<td>1.67 (1.29 to 2.15)</td>
<td>1.40 (1.06 to 1.85)</td>
</tr>
<tr>
<td>50th - 75th percentile vs. &lt; 50th percentile</td>
<td>1.38 (1.07 to 1.79)</td>
<td>1.14 (0.90 to 1.43)</td>
</tr>
<tr>
<td>&lt; 50th percentile vs. &lt; 75th percentile</td>
<td>1.58 (1.24 to 2.02)</td>
<td>1.29 (1.02 to 1.60)</td>
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<tr>
<td>Median household income (higher vs. lower)</td>
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<tr>
<td>Professional</td>
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The above results indicate health inequalities in Hong Kong that need to be tackled.

Similar to previous studies, health inequality could be occurring due to uneven distributions of socioeconomic status, occupations and racial/cultural backgrounds. Several studies found that income distribution could be a factor of health inequality among drug poisoning deaths. Previous research also indicated that age effect and racial background could be associated with drug-related deaths. In particular, a recent study has investigated drug-related mortality across the USA. Although this study found that drug mortality was generally found in counties at an economic disadvantage and more blue collar, counties with higher mortality associated with heroin and syndemic classes (counties with high mortality across all types of opioids) were more urban with larger concentrations of professional workers and less economically disadvantaged. Our results regarding deaths from other opioids echoed these studies, that being professionals and living in less economically disadvantaged neighborhoods may not have protective effects on drug-related mortality.

Advancing from the above studies, our results indicated that health inequalities could be associated with shifts in mortality patterns over time. The individual-level shift in mortality patterns could occur because of the affordability of drugs, no matter whether drugs were legally/illegal used. For drugs legally used for treatments, they may affect mortality risk due to medical needs and a lack of family support among vulnerable subpopulations. For example, oxycodone, an opioid pain reliever, has been registered in Hong Kong since 13 May 2010. However, oxycodone and other opioid pain relievers in Hong Kong are prescription drugs with high restrictions on use. Only tramadol may be a bit easier to buy in Hong Kong’s drug stores. This resulted in more common use of opioid pain relievers in private hospitals but not in public hospitals/clinics due to the liability/policy issues of medical doctors from public hospitals/clinics. Based on our results, drug poisoning deaths generally shifted to the middle-aged and young-old, widowed or divorced, economically active, white collar, non-local born, not being accidentally poisoned and exposure to narcotics and psychodysleptics. Subgroup analysis showed that deaths from other opioids shifted to the middle-aged, young-old and divorced; however, drug poisoning deaths did not shift towards either local born or non-local born. This could partially be explained by the socioeconomic status of local individuals. For those low-income individuals, they may be less able to afford registered drugs, such as opioid pain relievers, for medical treatments. This may result in a less fatal risk among these individuals in overdosing on registered drugs. However, middle-aged or young-old could be individualst with a higher socioeconomic status, at the same time facing frailty and other health risks from chronic diseases. In particular, a recent study in Hong Kong indicated that middle-aged and young-old could be subgroups with distinct chronic care needs, as these individuals were more often discharged inpatients with multimorbidity compared with older adults. Additionally, some of these individuals may have health insurance to cover the cost of medical treatments. This might lead to more intensive use of various drugs for medical treatments among these individuals, resulting in a higher risk of overdosing. For widowed and divorced, these individuals were people with less family support. Widowed and
divorced may also be associated with mental distress. However, other than good health, feeling supported by their families and friends, being financially secure, and living in a place with emotional ties, were also key for positive aging in Hong Kong. With a lack of family resilience and social support, widowed and divorced may rely on self-care and frequent use of registered drugs to reduce health burdens from chronic diseases and pains. Some of these individuals may also need to use psychoactive drugs for medical treatments. As more drugs have been legally used since 2011, inappropriate use of registered drugs may be the reason why drug overdose mortality has increased among these subgroups. Furthermore, although those locally born received extensive health education regarding the risk of illegal drug use, these individuals still had low awareness regarding the risk of using registered drugs. This may be the reason why there was no significant difference in shifts between local born and non-local born among deaths from other opioids. By comparison, the results showed that more deaths from heroin shifted towards non-local born, middle-aged and young-old, but less shifted towards never married and economically inactive over time. This implies that the individuals consuming drugs illegally could be richer subpopulations and with different cultural backgrounds from the Hong Kong-born, while the reasons for taking drugs illegally among these individuals were not related to their personal health status or family issues. Specifically, the insignificant results from shifts in the length of stay in Hong Kong indicated that influences of cultural practice and racial background on drug use may be unable to be modified by the duration of residence.

The results regarding neighborhood-level mortality shifts were also aligned with the above findings. Specifically, deaths were significantly shifted towards areas with more high-education individuals and a mix of private/public housing residents. It further implies that higher education did not help individuals to understand the negative consequences of registered drug abuse. For the areas with a mix of private/public housing residents, it pinpointed that the middle class were the most at-risk subpopulation. In particular, these neighborhoods were usually the areas with greater accessibility to drug stores and commercial facilities due to urban planning/design, and individuals in these neighborhoods could be people with greater ability to buy drugs due to their income and related socioeconomic status.

To reduce the health inequalities in a high-density Asian city, we therefore urge medical officials to provide more recommendations for non-pharmacological interventions to the patients. This recommendation is not only for Hong Kong, but also for other high-density Asian cities. In particular, economic inequality and social problems of internal/international migrants have been common issues in many high-density Asian cities, such as Hong Kong, Shanghai, Delhi and Singapore. Although the magnitude of economic inequality and reasons for internal/international migration may be different among these locations, the above problems can still be linked to issues of drug affordability and different cultural practice/racial background noted in our results. Therefore, it is necessary to provide non-pharmacological interventions to patients as a type of preventive medicine to reduce the risk of overdosing on drugs. These non-pharmacological interventions could include physiotherapy, counseling and meditation services and group activities for physical activities. For pharmacological interventions, a lower dose could be an alternative solution if it is appropriate for medical treatments. Furthermore, workshops regarding ‘knowledge, attitude and practice’ should be provided to patients to improve their health behaviors and understanding of drug-related risks, as duration of residence may not influence cultural/health practices.

There were several limitations: (1) this study was conducted based on the ICD code information. Although the ICD code had various codes to classify subgroups of drug poisoning deaths, it was unable to identify causes from specific drugs such as oxycodone. Using cohort data with detailed medical records related to drug use/treatments may be more comprehensive. However, cohort data are hard to collect and can be associated with ethical issues. Our approach using a territory-wide death registry for rapid assessment is still appropriate; (2) this study did not control temporal variations such as seasonality, holiday effects and weekday/weekend effects. As our model was to compare the long-term temporal difference of 2001–2010 with 2011–2016, our results are still valid. Future studies could consider including these effects of temporal variations as modifiers to evaluate their additional impacts on drug poisoning deaths; and (3) this study assumed that spatial variation of neighborhood deprivation did not have a significant change over time. For future studies with a longer time window, it will be necessary to evaluate the effect modification from spatiotemporal change of neighborhood deprivation.

Conclusions

This study evaluated the shifts in mortality patterns among drug poisoning deaths over time in a high-density Asian city. Our results indicate a significant shift due to health inequalities in Hong Kong. The results pinpoint the needs for health education among the local population, especially those mid- or high-income individuals, regarding how to use registered drugs for medical treatments appropriately.

Authors’ contributions: HCH conceived the study design, conducted data analysis and wrote the draft manuscript. SW and CWC provided medical implications and commented on the manuscript. All authors approved the final draft of the manuscript.

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Competing interests: There are no competing interests.

Ethical approval: The study was approved by the Human Research Ethics Committee of The University of Hong Kong (Reference Number: EA2002023).

Data availability: The datasets generated and/or analyzed during the current study are not publicly available but may be available on reasonable request.
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