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Using geographic information systems to compare the density of stores selling tobacco and alcohol: youth making an argument for increased regulation of the tobacco permitting process in Worcester, Massachusetts, USA

Yelena Ogneva-Himmelberger, 1 Laurie Ross, 1 William Burdick, 1 Sheryl-Ann Simpson 2

ABSTRACT
Background This study is based on a community participatory research (CBPR) partnership between a youth group and a local university to explore whether greater regulation of tobacco permits would reduce the density of tobacco outlets overall, and particularly in low-income, high minority neighbourhoods in Worcester, Massachusetts, USA.

Methods Applying Geographic Information Systems and regression analyses to neighbourhood demographics and the location of stores selling tobacco and alcohol, the study predicts the density of tobacco outlets as compared to alcohol outlets at the neighborhood block group level and in relation to the location and demographic composition of public schools.

Results This study found that there are more than double the number of stores that sell tobacco as compared to alcohol in the city of Worcester. For every alcohol vendor there was a 41% increase in the estimated number of tobacco vendors, independent of the effect of other variables. The likelihood of having a tobacco outlet located near a school was greater than having an alcohol outlet as the percentage of minority students in schools increases.

Conclusions Based on these findings, the authors conclude that to reduce the impact of tobacco on socially and economically disadvantaged communities, the issuing of tobacco permits requires more regulation and oversight and should take into consideration the density and actual location of other licensees in an area.

INTRODUCTION
Tobacco and alcohol have serious short-term and long-term health consequences for users and individuals exposed to these products. Both are associated with cancer and birth defects. Tobacco contributes to pulmonary and cardiovascular diseases. The Centers for Disease Control estimate that cigarette smoking is responsible for 438,000 deaths a year in the US, 38,000 are a result of exposure to secondhand smoke.1 Long-term alcohol use damages the liver, cognitive functions and the nervous system; it negatively impacts mental health. According to Mothers Against Drunk Driving, in 2006 an estimated 17,602 people died in alcohol-related traffic crashes.2 The health outcomes of smoking and alcohol consumption are experienced disproportionately by people of colour, low-income populations and youth.3 In spite of similar health threats and greater mortality associated with tobacco, in Massachusetts, there is far greater oversight and control over alcohol licensing.4

Regulating outlet density is being looked at as a ‘new frontier for tobacco control’5–8 Higher tobacco outlet density in an area is associated with an increased likelihood of smoking.6 Several studies have shown that there is a positive association between tobacco outlet density and the level of minority and low-income residents at the Census tract and block group levels.8,10 Researchers have found a positive relationship between a neighbourhood’s smoking rate and the concentration of convenience stores.11 Zoning ordinances that limit where tobacco can be sold and increased regulation over the permitting process are seen as environmental strategies with promise to reduce tobacco consumption and to reduce harm to vulnerable populations.5–8

Although experts have recommended addressing outlet density by restricting the number of tobacco permits,6–7 to date no such strategy has been tried in Massachusetts. Currently in Worcester, Massachusetts, the site of this research, it is vastly easier to get a tobacco permit than it is to get an alcohol license. A tobacco permit requires applicants to fill out a one-page form, prove that they are contributing to workers’ compensation and pay a $100.00 annual fee. Alcohol licenses require filling out a 19-page form, providing a list of abutters who must be notified about the intent to get a license, filling out over a dozen additional forms, providing evidence of the owner’s citizenship and that he/she does not have a criminal record. In addition to paying roughly $300 in filing fees, the licenses can cost up to $3000. All applicants for liquor licenses must appear before the License Commission where abutters and other interested parties may provide evidence why the license should not be issued. Grounds for denial include that an area already has sufficient licenses to meet the demand.12

This paper is based on a community based participatory research (CBPR) partnership between a youth group and a local university and uses Geographic Information Systems (GIS) and statistical analyses to explore whether greater regulation of tobacco permits would reduce the density of tobacco outlets overall, and particularly in low-income, high-minority neighbourhoods in Worcester,
Massachusetts. This was done by using neighbourhood demographics to predict the density of tobacco outlets as compared to alcohol outlets. Alcohol was used as a point of comparison because there is more regulation over the density of alcohol outlets.

METHODS

With a population of roughly 174,000, Worcester, Massachusetts is the second largest city in New England after Boston. The adolescent population is roughly 25,000 and 25.1% of children in Worcester live in poverty. The city’s population is 70% Caucasian, yet the Worcester Public Schools are 42.5% Caucasian, indicating that Worcester is a community where non-Caucasians constitute the majority of the student population. The Healthy Options for Prevention and Education (HOPE) coalition—the community partner driving this research—is a youth—adult partnership that formed in 2000 to reduce youth violence and alcohol, tobacco and other drug use, and promote positive mental health and youth voice. The 20 HOPE Peer Leaders are all African-American, Latino, or multiracial and are between 15–19 years old. Community Based Participatory Research (CBPR) shaped the research approach. The explicit focus of CBPR is to eliminate health disparities and to promote community change through a research and action cycle in which the knowledge and concerns of community members drive the process and are supported by outside researchers. CBPR has been used to work with young people of colour on public health issues. Youth in the HOPE Coalition were concerned that tobacco and alcohol manufacturers use target marketing practices toward youth of colour in urban areas to get them to purchase their products. This concern led them to partner with a local university to systematically examine the geographic distribution of stores and point-of-sale advertising.

GIS tools for mapping, analysis and visualisation are increasingly important in urban decision making and policy. Participatory community projects use GIS to examine trends, advocate for local issues, insert local knowledge into policy debates and preserve local histories. Several studies have used GIS to examine the relationship between alcohol retail outlets and neighbourhood violence. Studies are beginning to take the further step of explicitly addressing the environmental justice issues of advertising, placement and concentration of alcohol and tobacco retail in cities.

In this study we used several sources of publicly available data. We obtained lists of current tobacco and alcohol licenses from Worcester Health Department and License Commission and geocoded them (100% geocoding rate was achieved thanks to the high accuracy of the address reference table). In total, 289 tobacco vendors and 119 alcohol vendors were mapped; 41 vendors had tobacco permits and alcohol licenses. Restaurants that sell alcohol were excluded from our analysis due to their lack of outside advertising and the lower probability that youth can purchase alcohol. Data on income and ethnic composition of public schools were downloaded from Massachusetts Department of Elementary and Secondary Education website (http://profiles.doe.mass.edu/). Median household income, percentage minority and total population data by census block groups were obtained from MassGIS (http://www.mass.gov/mgis/).

GIS and regression analyses were used to analyse vendor locations in relationship to sociodemographics of the city and in relationship to public schools. Using the spatial join technique in ArcGIS V9.3 software (ESRI, 2009. Environmental Systems Research Institute -http://www.esri.com/software/arcgis/), the numbers of tobacco and alcohol vendors per 1000 people were calculated for each census block group. To examine vendors’ distribution in relationship to the income level, all 167 block groups were divided into 5 categories based on state definitions of low (<$25,000/year), medium ($2500–75,000/year) and high (> $75,000/year) household income. Block groups were also divided into three categories based on percentage minority population (minority is defined as ‘non-Caucasian population’ following the definition by MassGIS). The average numbers of tobacco and alcohol vendors were calculated separately for each category using attribute and spatial query tools in GIS. Differences in average values between groups were evaluated using the Kruskal–Wallis test, a non-parametric statistical test, due to the highly skewed distribution of the data. To understand the relationship between economic and social disadvantage and the density of tobacco outlets, we ran Poisson and negative binomial regressions using density of alcohol outlets, percentage low-income population and percentage minority population as independent variables.

We also analysed the proximity of schools to tobacco and alcohol vendors in the city. There are a total of 47 public schools in Worcester. Using ‘selection by location’ tools in GIS, these schools were divided in two groups: those that are less than 1000 feet (approximately 300 m) from the nearest tobacco vendor and those farther than 1000 feet. The 1000-foot threshold was chosen based on current and proposed laws as well as previous studies. We used logistic regression to calculate the probability of having an alcohol or tobacco vendor within 1000 feet from schools, based on the sociodemographic characteristics of student population. The dependent variable is presence/absence of the vendor(s) in the 1000-foot buffer. Three independent variables were included in this analysis: limited English proficiency (LEP), percentage minority and percentage low income. We eliminated citywide magnet schools twelve and high schools four that served a larger geographical area than a neighbourhood because most of the students who attend these
neighbourhoods with between 0% and 12% minority, there were significant differences in alcohol and tobacco outlet density between communities with different socioeconomic characteristics. GIS analysis shows that the tobacco and alcohol outlet density is not evenly distributed throughout the city (see figures 1 and 2). The spatial patterns of tobacco and alcohol vendors were similar and focused within the downtown area and the southern neighbourhoods.

Table 1 presents data that indicate a statistically significant relationship exists between social and economic characteristics of residents and outlet density patterns. For neighbourhoods with between 0% and 12% minority, there were 0.98 stores that sell tobacco per 1000 people. For neighbourhoods with between 12% and 30% minority, there were 2.08 stores, and for neighbourhoods with over 30% minority, there were 2.62 stores per 1000 people. For neighbourhoods with mean household incomes greater than $75,000, there were 0 stores that sell tobacco per 1000 people. For neighbourhoods with a mean household income between $25,000 and $75,000, there were 1.79 stores per 1000 people, and for neighbourhoods with a mean household income less than $25,000, there were 3.03 stores per 1000 people. These findings support findings from other studies showing that low-income and minority populations are significantly more exposed to tobacco outlets than Caucasian and higher income populations.3 8

Looking at alcohol outlets in tables 1 and 2, for low-minority neighbourhoods, there were 0.41 stores that sell alcohol per 1000 people. For high-minority neighbourhoods there were 1.52 stores per 1000 people. For low median household income neighbourhoods there were 1.75 stores that sell alcohol per 1000 people, while for high median household income neighbourhoods there were 0 stores per 1000 people. The Kruskal–Wallis test showed that differences between groups were statistically significant, confirming that high-minority and low-income populations are significantly more exposed to alcohol and tobacco than Caucasian and higher income populations.

Based on differences in the ways these two products are regulated, it is not surprising that the city has more tobacco outlets than alcohol outlets. Neighbourhoods with the highest levels of low-income populations and minorities also have the highest density of stores that sell tobacco and alcohol. While the density of tobacco vendors is higher than the density of alcohol vendors for all socioeconomic groups, when the densities are compared within each group an interesting pattern can be observed (table 1): the ratio of tobacco outlets to alcohol outlets is the highest in medium income neighbourhoods (2.6) and in those with the lowest proportion of minorities (2.8). This pattern suggests that the existing land use and regulatory limitations on the number of alcohol outlets allowed has greatly reduced the presence of stores that sell alcohol in higher income neighbourhoods with higher percentages of Caucasian residents.

To understand the relationship between economic and social disadvantage and the number of tobacco outlets, we ran Poisson regressions using the number of tobacco outlets as the dependent variable and the number of alcohol outlets, percentage low-income population and percentage minority population as independent variables. We used population as the offset term in the regression to account for variation in population size in census block groups. Poisson regression results indicated the presence of overdispersion in the data (deviance ratio=2.46 and Pearson statistic ratio=2.94). To address the overdispersion problem, we then ran negative binomial regression with the same set of variables, which resulted in a better model fit (deviance ratio=0.90 and Pearson statistic ratio=0.91). Table 3 shows the results of these models. The coefficients for all three independent variables were positive, indicating that the areas with a higher percentage of low-income and minority populations, and a higher number of

Table 1

<table>
<thead>
<tr>
<th>Percentage minority population</th>
<th>Tobacco/ minority</th>
<th>Tobacco/ income</th>
<th>Alcohol/ minority</th>
<th>Alcohol/ income</th>
</tr>
</thead>
<tbody>
<tr>
<td>0% to 12% (49)</td>
<td>1.15</td>
<td>0.41</td>
<td>2.80</td>
<td>1.32</td>
</tr>
<tr>
<td>12% to 30% (56)</td>
<td>2.08</td>
<td>0.80</td>
<td>2.60</td>
<td>1.88</td>
</tr>
<tr>
<td>30% to 69% (62)</td>
<td>2.62</td>
<td>1.32</td>
<td>1.98</td>
<td>NA</td>
</tr>
<tr>
<td>Median household income</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Below $25000 (35)</td>
<td>3.03</td>
<td>1.75</td>
<td>1.73</td>
<td>1.25</td>
</tr>
<tr>
<td>$25000—$75000 (128)</td>
<td>1.79</td>
<td>0.69</td>
<td>2.59</td>
<td>0.64</td>
</tr>
<tr>
<td>Over $75000 (4)</td>
<td>0.33</td>
<td>0.33</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Overall mean (SD)</td>
<td>2.01 (3.41)</td>
<td>0.90 (3.12)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The number in parenthesis corresponds to the number of block groups within each category.

Figure 2 Distribution of package stores and bars and median household income for census block groups in Worcester, Massachusetts, USA.

Schools live far away and use school buses. Neighbourhood schools serve the immediate surrounding area and many students walk to school. Since we are interested in youth exposure to alcohol and tobacco in areas where they live, we focused our analysis on 31 neighbourhood schools.

RESULTS

There were 2.01 stores per 1000 people that sell tobacco and 0.90 stores per 1000 people that sell alcohol in Worcester at time of assessment. GIS analysis shows that the tobacco and alcohol vendors were not distributed evenly throughout the city (see figures 1 and 2). The spatial patterns of tobacco and alcohol vendors were similar and focused within the downtown area and the southern neighbourhoods.

Tables 1 and 2 present data that indicate a statistically significant relationship exists between social and economic characteristics of residents and outlet density patterns. For neighbourhoods with between 0% and 12% minority, there were

Table 2 Results of Kruskal–Wallis test for differences in alcohol and tobacco vendors between three population groups

<table>
<thead>
<tr>
<th></th>
<th>Tobacco/ minority</th>
<th>Tobacco/ income</th>
<th>Alcohol/ minority</th>
<th>Alcohol/ income</th>
</tr>
</thead>
<tbody>
<tr>
<td>γ² test</td>
<td>11.130</td>
<td>8.929</td>
<td>10.206</td>
<td>7.321</td>
</tr>
<tr>
<td>Degrees of freedom</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Asymptotic significance</td>
<td>0.004</td>
<td>0.012</td>
<td>0.006</td>
<td>0.026</td>
</tr>
</tbody>
</table>

0.98 stores that sell tobacco per 1000 people. For neighbourhoods with between 12% and 30% minority, there were 2.08 stores, and for neighbourhoods with over 30% minority, there were 2.62 stores per 1000 people. For neighbourhoods with median household incomes greater than $75,000, there were 0 stores that sell tobacco per 1000 people. For neighbourhoods with mean household income between $25,000 and $75,000, there were 1.79 stores per 1000 people, and for neighbourhoods with a mean household income less than $25,000, there were 3.03 stores per 1000 people. These findings support findings from other studies showing that low-income and minority populations are significantly more exposed to tobacco outlets than Caucasian and higher income populations.3 8

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Based on differences in the ways these two products are regulated, it is not surprising that the city has more tobacco outlets than alcohol outlets. Neighbourhoods with the highest levels of low-income populations and minorities also have the highest density of stores that sell tobacco and alcohol. While the density of tobacco vendors is higher than the density of alcohol vendors for all socioeconomic groups, when the densities are compared within each group an interesting pattern can be observed (table 1): the ratio of tobacco outlets to alcohol outlets is the highest in medium income neighbourhoods (2.6) and in those with the lowest proportion of minorities (2.8). This pattern suggests that the existing land use and regulatory limitations on the number of alcohol outlets allowed has greatly reduced the presence of stores that sell alcohol in higher income neighbourhoods with higher percentages of Caucasian residents.

To understand the relationship between economic and social disadvantage and the number of tobacco outlets, we ran Poisson regressions using the number of tobacco outlets as the dependent variable and the number of alcohol outlets, percentage low-income population and percentage minority population as independent variables. We used population as the offset term in the regression to account for variation in population size in census block groups. Poisson regression results indicated the presence of overdispersion in the data (deviance ratio=2.46 and Pearson statistic ratio=2.94). To address the overdispersion problem, we then ran negative binomial regression with the same set of variables, which resulted in a better model fit (deviance ratio=0.90 and Pearson statistic ratio=0.91). Table 3 shows the results of these models. The coefficients for all three independent variables were positive, indicating that the areas with a higher percentage of low-income and minority populations, and a higher number of

The number in parenthesis corresponds to the number of block groups within each category.
In other words, the odds of having a tobacco outlet in the 1000-foot buffer around schools. These odds multiply by \( \exp(0.116) \) we can calculate the odds of having a tobacco outlet in

Significant variable, and percentage LEP was not significant. Based on the value of the coefficient for percentage minority (0.116) we can calculate the odds of having a tobacco outlet in the 1000-foot buffer around schools. These odds multiply by \( \exp(0.116) = 1.123 \) for every 1-unit increase in percentage minority. In other words, the odds of having a tobacco outlet in the 1000-foot buffer increase by 12.5% with each 1% increase in the proportion of minority population. However, the odds of having an alcohol vendor in the 1000-foot buffer around schools multiply by \( \exp(0.077) = 1.08 \) for every 1-unit increase in percentage minority. It means that the odds of having an alcohol outlet in the 1000-foot buffer increase 8% with each 1% increase in the proportion of minority population. Therefore, the likelihood of having an outlet near a school increases more for tobacco vendors than for alcohol vendors (12.5% vs 8%) when the percentage of minority students in schools increases.

### DISCUSSION

The primary aim of this research was to compare the density of stores that sell tobacco to alcohol in order to explore whether stricter regulation of tobacco permitting would result in fewer tobacco outlets overall and have them less concentrated in neighbourhoods characterised by social and economic disadvantage.

Our findings confirm what other researchers have found about concentration of tobacco in low-income communities of colour. \(^4\) We also found that there were more than double the number of stores that sell tobacco as compared to alcohol. Both types of stores are more concentrated in neighbourhoods characterised by socioeconomic disadvantage. Interestingly, we found that the ratio of tobacco outlets to alcohol outlets was the highest in medium income neighbourhoods and in those with the lowest proportion of minorities. This result indicates that it is easier to obtain tobacco permits in all neighbourhoods and suggests that the alcohol regulations provide leverage to wealthier neighbourhoods with a higher percentage of Caucasian populations to restrict the number of alcohol licenses.

If we only look at ratios of tobacco to alcohol, it appears that limiting tobacco permits would benefit wealthier areas more than the more disadvantaged neighbourhoods. Yet, as our objective is to have an impact on tobacco regulation with the ultimate goal of limiting the number of tobacco permits issued annually, we focused on the absolute number of vendors of these products, because the ratio does not give a sense of the magnitude of the problem (ie, the ratio of 2 may mean that there are 2 tobacco vendors and 1 alcohol vendor OR that there are 10 vendors of each, which is much more worrying).

### Table 3: Poisson and negative binomial regression results

<table>
<thead>
<tr>
<th>Model: Poisson regression</th>
<th>Independent variables</th>
<th>B</th>
<th>Standard error</th>
<th>95% CI</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of alcohol outlets</td>
<td>0.181</td>
<td>0.0114</td>
<td>0.159 to 0.204</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>Percentage low income</td>
<td>0.007</td>
<td>0.0047</td>
<td>-0.002 to 0.016</td>
<td>0.127</td>
</tr>
<tr>
<td></td>
<td>Percentage minority</td>
<td>0.003</td>
<td>0.0036</td>
<td>-0.004 to 0.010</td>
<td>0.433</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Model: negative binomial regression</th>
<th>Independent variables</th>
<th>B</th>
<th>Standard error</th>
<th>95% CI</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of alcohol outlets</td>
<td>0.343</td>
<td>0.0281</td>
<td>0.182 to 0.504</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>Percentage low income</td>
<td>0.003</td>
<td>0.0082</td>
<td>-0.014 to 0.019</td>
<td>0.750</td>
</tr>
<tr>
<td></td>
<td>Percentage minority</td>
<td>0.011</td>
<td>0.0059</td>
<td>0.000 to 0.023</td>
<td>0.050</td>
</tr>
</tbody>
</table>

### Table 4: Limited English language proficiency (LEP), family income status and racial composition of students in relationship to schools’ proximity to tobacco and alcohol vendors (total number of schools = 31)

<table>
<thead>
<tr>
<th>Percentage of students with LEP</th>
<th>Percentage of low-income students</th>
<th>Percentage Caucasian</th>
</tr>
</thead>
<tbody>
<tr>
<td>Schools within 1000 feet of tobacco vendor (18), mean (SD)</td>
<td>26.6 (15.5)</td>
<td>76.4 (16.5)</td>
</tr>
<tr>
<td>Schools farther than 1000 feet of tobacco vendor (13), mean (SD)</td>
<td>17.6 (11.2)</td>
<td>51.8 (22.8)</td>
</tr>
<tr>
<td>Schools within 1000 feet of alcohol vendor (12), mean (SD)</td>
<td>24.9 (16.2)</td>
<td>73.3 (24.8)</td>
</tr>
<tr>
<td>Schools farther than 1000 feet of alcohol vendor (19), mean (SD)</td>
<td>20.9 (11.5)</td>
<td>60.1 (21.0)</td>
</tr>
</tbody>
</table>

The number in parenthesis corresponds to the number of schools within each category.
tobacco vendors and 5 alcohol vendors). By focusing on the absolute number of vendors we were able to better address the issue of control over tobacco licenses.

Indeed, our comparison of the total numbers of both types of outlets support calls for greater regulation of tobacco permitting to address tobacco outlet density. Yet, as alcohol is also more likely to be in disadvantaged areas—albeit at lower levels—the results suggest that to really reduce the impact on socially and economically disadvantaged communities, the tobacco permitting process would require a high level of specificity. It would have to take into consideration the density and actual location of other licensees in an area to ensure, for example, that there are not stores with licenses on every corner of an intersection. GIS can be used to facilitate this process.

There are several limitations to this study. Firstly, it analyses density patterns only in one city. In order to provide greater weight to the recommendation to regulate the density of tobacco permits, similar studies—taking into consideration local regulations for alcohol licensing—should be conducted. Secondly, this study uses 2000 Census data and 2006 tobacco permit and alcohol license data. This temporal mismatch could introduce bias into the results.

### What this paper adds

- Tobacco and alcohol have serious short-term and long-term health consequences for users and individuals exposed to such products. In spite of similar health threats and greater mortality associated with tobacco, there tends to be far greater oversight and control over alcohol licensing than tobacco permitting in the US. Numerous studies have shown that there is a positive association between tobacco outlet density and the level of minority and low-income residents, as well as between outlet density and smoking rates.
- This study found that there are more than double the number of stores that sell tobacco as compared to alcohol in the city of Worcester, Massachusetts, USA. For every alcohol vendor there was a 41% increase in the estimated number of tobacco vendors, independent of the effect of other variables. The likelihood of having a tobacco outlet located near a school was greater than having an alcohol outlet as the percentage of minority students in schools increases.
- Based on these findings, we conclude that to reduce the impact of tobacco on socially and economically disadvantaged communities, the issuing of tobacco permits requires more regulation and oversight and should take into consideration the density and actual location of other licensees in an area.

### Conclusions

The HOPE Peer Leaders shared these findings with city and state officials, local business associations, substance abuse coalitions and, most notably, Worcester’s Board of Health in November 2009. Upon hearing the Peer Leaders’ presentation, the Board of Health unanimously voted to put a cap on the number of tobacco permits the city issues each year. Their vote was referred to the city’s legal department to explore the ramifications of this action. If there are no legal objections, Worcester would become the first community in Massachusetts to limit the number of tobacco permits that are issued each year.

This CBPR study suggests that changes in policy regarding tobacco permitting could make great strides toward reducing the health disparities and the environmental injustice of the distribution of tobacco in Worcester. Other communities may want to look at this policy option as well. Our application of GIS adds to the literature on the use of this powerful tool in community based participatory research. It shows that a collaborative work between youth and researchers can lay the foundation for groundbreaking policy change.

### Acknowledgements

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### Competing interests

None.

### Provenance and peer review

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### REFERENCES

Research paper