“At-risk” places: Inequities in the distribution of environmental stressors and prescription rates of mental health medications in Glasgow, Scotland

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This study examines the potential association between one aspect of the built environment, namely, the concentration of vacant and derelict land (VDL), and the prevalence of mental health disorders (using the proxy variable of mental health drug prescription rates), in Glasgow, Scotland.

Previous research (Maantay, 2013) demonstrated the spatial correspondence between the locations of VDL in Glasgow and several adverse health outcomes (i.e., low male life expectancy, and high rates of respiratory hospitalizations, cancer hospitalizations, and low birth weight infants).
Glasgow, Scotland:
~ Population: 600,000;
~ UK’s least healthy city;
~ Highest total acreage amount and proportion of vacant and derelict land (VDL) of any area in Scotland;
~ Much of VDL is contaminated by former industrial land uses;
~ VDL is often currently used as dumping grounds;
~ VDL is concentrated in high deprivation areas.
‘At-Risk’ Places: Environmental Stressors and Adverse Health Outcomes in Glasgow

Vacant and Derelict Land (VDL) in Glasgow

‘Characteristics of places may be as important as the characteristics of people for an understanding of particular patterns of health,’ (Phillimore, P., 1993:176. How do places shape health? Rethinking locality and lifestyle in North-east England, in Platt, S., ed., Locating Health: Sociological and Historical Implications).
At-Risk' Places: Environmental Stressors and Adverse Health Outcomes in Glasgow

Distribution of vacant and derelict land (VDL) in Glasgow

Scottish Index of Multiple Deprivation (SIMD), which is comprised from domains including health, education, income, employment, geographic access, immigrant status, English language ability, housing, crime, etc. Higher SIMD scores indicate higher levels of deprivation.

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Acronyms:
SIMD = Scottish Index of Multiple Deprivation;
MLE = Male Life Expectancy;
RESP = Respiratory Hospitalization Rate per 100,000;
CANCER = Cancer Hospitalization Rate per 100,000;
LBW = Low Birth Weight Babies as a Percentage of Live Births;
VDL = Proximity to Vacant or Derelict Land.

‘At-Risk’ Places: Environmental Stressors and Adverse Health Outcomes in Glasgow

## Characteristics of vacant and derelict land in Glasgow

<table>
<thead>
<tr>
<th>Category</th>
<th>Number of Sites (count)</th>
<th>Area (hectares)</th>
<th>Number of Sites (%)</th>
<th>Area (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>264</td>
<td>247.6</td>
<td>28.5</td>
<td>19.0</td>
</tr>
<tr>
<td>Unknown</td>
<td>174</td>
<td>166.1</td>
<td>18.8</td>
<td>12.7</td>
</tr>
<tr>
<td>Other&lt;sup&gt;a&lt;/sup&gt;</td>
<td>100</td>
<td>153.4</td>
<td>10.8</td>
<td>11.8</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>71</td>
<td>152.9</td>
<td>7.7</td>
<td>11.7</td>
</tr>
<tr>
<td>Agricultural</td>
<td>19</td>
<td>126.5</td>
<td>2.0</td>
<td>9.7</td>
</tr>
<tr>
<td>Education</td>
<td>91</td>
<td>124.7</td>
<td>9.8</td>
<td>9.6</td>
</tr>
<tr>
<td>Transport</td>
<td>69</td>
<td>109.7</td>
<td>7.4</td>
<td>8.4</td>
</tr>
<tr>
<td>Recreation &amp; Leisure</td>
<td>35</td>
<td>81.0</td>
<td>3.8</td>
<td>6.2</td>
</tr>
<tr>
<td>General Industry (excl. manufacturing)</td>
<td>57</td>
<td>74.4</td>
<td>6.1</td>
<td>5.7</td>
</tr>
<tr>
<td>Community &amp; Health</td>
<td>47</td>
<td>67.0</td>
<td>5.1</td>
<td>5.1</td>
</tr>
<tr>
<td><strong>TOTALS</strong></td>
<td><strong>927</strong></td>
<td><strong>1303.2</strong></td>
<td><strong>100</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

<sup>a</sup> Other category includes: mineral activity, storage (gas, oil, other), passive open space, wholesale distribution, retailing, utility services, forestry/woodland, offices, business class, and other.
Prescription rates for mental health medications by Data Zones, with VDL polygons.

VDL density surface, using Kernel Density Estimation (KDE) to measure potential exposure to the VDL.

Descriptive statistics for bivariate and regression model variables, based on Glasgow data zones (n = 690; 4 DZs were omitted from the analysis due to low population numbers).

<table>
<thead>
<tr>
<th>Variable</th>
<th>n</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>VDL Density</td>
<td>690</td>
<td>.09</td>
<td>3670.73</td>
<td>614.40</td>
<td>590.84</td>
</tr>
<tr>
<td>SIMD Score</td>
<td>690</td>
<td>1.80</td>
<td>87.75</td>
<td>35.96</td>
<td>22.07</td>
</tr>
<tr>
<td>MH Prescription Rates (proportion)</td>
<td>690</td>
<td>.06</td>
<td>.22</td>
<td>.12</td>
<td>.03</td>
</tr>
<tr>
<td>Geographic Accessibility Score</td>
<td>690</td>
<td>.07</td>
<td>43.74</td>
<td>9.84</td>
<td>8.48</td>
</tr>
<tr>
<td>National Origin (% non-UK)</td>
<td>690</td>
<td>.48</td>
<td>58.82</td>
<td>11.58</td>
<td>9.72</td>
</tr>
<tr>
<td>Percent of adults without qualifications</td>
<td>690</td>
<td>2.40</td>
<td>64.38</td>
<td>33.88</td>
<td>15.02</td>
</tr>
</tbody>
</table>

There is a strong spatial correspondence between the areas with high SIMD (high deprivation) and the locations of VDL. This was statistically verified by running a simple Pearson Correlation between VDL density and the SIMD score by DZ.

\[ r = .521, p < .001 \]

This positive association suggests that areas with elevated deprivation scores tend to also have higher exposures to vacant and derelict land, confirming the presence of an environmental justice issue in terms of potential environmental stressors.
Statistical Analysis

The relationship between the density of VDL and the proportion of the population per DZ who were prescribed medicine for anxiety, depression, or psychosis was explored using three models: an ordinary least squares regression (OLS), a spatial autoregressive (SAR) model (spatial lag model), and a geographically weighted regression (GWR).

All models were parameterized the same way, with the mental health (MH) prescription rate as the dependent variable and (1) VDL density; (2) percent of adults without qualifications; (3) geographic access to basic services; and (4) percent non-UK born as the independent variables.
Ordinary least squares regression results (dependent variable = prescription rate for mental health medications (for anxiety, depression, or psychosis). $R_a^2 = .573$, AIC = -3679. Condition index is 8.988, suggesting that co-linearity is unlikely to be an issue.

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>Standardized Coefficients</th>
<th>t</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>VDL Density</td>
<td>0.171</td>
<td>6.076</td>
<td>0.000</td>
</tr>
<tr>
<td>Percent without Qualifications</td>
<td>0.534</td>
<td>17.387</td>
<td>0.000</td>
</tr>
<tr>
<td>Geographic Access Score</td>
<td>0.058</td>
<td>2.265</td>
<td>0.024</td>
</tr>
<tr>
<td>Percent non-UK country of birth</td>
<td>-0.244</td>
<td>-8.468</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Spatial autoregressive model (lag model) ML estimation results (dependent variable = prescription rates for mental health medications. Pseudo $R^2 = 0.89$, AIC = -4504. Lagged MH Prescription Rate refers to the spatially lagged version of the dependent variable created based on queen contiguity.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std.Error</th>
<th>z-value</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>VDL Density</td>
<td>$1.40 \times 10^{-6}$</td>
<td>$6.0 \times 10^{-7}$</td>
<td>2.25</td>
<td>0.025</td>
</tr>
<tr>
<td>Geographic Access Score</td>
<td>$-6.49 \times 10^{-5}$</td>
<td>$3.98 \times 10^{-5}$</td>
<td>-1.63</td>
<td>0.103</td>
</tr>
<tr>
<td>Percent without Qualifications</td>
<td>$2.64 \times 10^{-4}$</td>
<td>$3.06 \times 10^{-5}$</td>
<td>8.65</td>
<td>0.000</td>
</tr>
<tr>
<td>Percent non-UK country of birth</td>
<td>$-1.63 \times 10^{-4}$</td>
<td>$3.89 \times 10^{-5}$</td>
<td>-4.17</td>
<td>0.000</td>
</tr>
<tr>
<td>Lagged MH Prescription Rate</td>
<td>0.831</td>
<td>0.0186</td>
<td>44.59</td>
<td>0.000</td>
</tr>
</tbody>
</table>
A geographically weighted regression, specified the same way as the global models, was performed to explore potential spatial non-stationarity in the associations. This local approach allows the relationships (e.g., the variable coefficients) to vary over space by essentially performing one local regression for each DZ in Glasgow, and as such can aid in identifying areas which behave in unexpected ways.

In the case of this study, GWR was used in an exploratory way to examine the spatial variation of the relationships and subsequently generate hypotheses as to the cause of the spatial heterogeneity.

An adaptive kernel was used, employing 65 “neighbors” per local regression as determined by minimizing the AICc, which helps to quantify model performance. The model diagnostics ($AIC = -4357$, $\text{pseudo } R^2_a = 0.89$) suggest a good performing model.
Local $R^2$ from the GWR model. Lighter shaded DZs suggest a weaker local model where the MH prescription rates are not as closely associated with the explanatory variables.

VDL Coefficient from the GWR model. Darker shades = DZs with larger coefficients (larger influence of VDL on MH prescription rates). The map shows where the model behaved “as expected,” with positive association between VDL density and MH prescription rate, while adjusting for the other socio-demographic indicators, and where it behaved counter-intuitively (weak or negative association between VDL density and MH prescription rate).
Qualitative Assessment - Pilot Study Areas

Geographic features are often assumed to be similar in studies analyzing equity in access. One of the points of a qualitative assessment is to make clear that the characteristics of the features are likely to have an impact on the health effects, and those qualitative characteristics aren’t often considered in these types of studies.

It should be noted that the statistical analyses did not take into account characteristics of the VDL other than area (converted to density), and it seems clear that not all VDL would have the same potentially deleterious effect on nearby populations. For instance, vacant land which is currently used as an informal dumpsite may act as a more potent psycho-social stressor than one which is more pleasant-looking or benign and used as a playing field for children or youth.

In order to explore how VDL characteristics might impact MH prescription rates, a more qualitative assessment was conducted on two pilot areas, which were selected to be illustrative of many of the VDL environments. Two sites were identified and selected from relatively high-VDL density areas, but ones which behaved differently from one another in the GWR model: one where VDL is a relatively strong predictor of MH prescription rates, versus one where it is weaker. These sites were then examined in more detail using a combination of data sources, including historical ordnance survey maps and GoogleEarth’s Street View.
Ordnance Survey (top) and 2012 GoogleEarth view (bottom – looking roughly southeast) of former bus garage in Possil Park. VDL is outlined in red.

**Pilot Site 1** consists of land that was formerly used as a bus garage in Possil Park (an identified PARDLI area), which became derelict between 2001 and 2004.

It is within a DZ that shows GWR characteristics of a relatively strong local $R^2$ (0.64) and positive VDL coefficient.

This suggests an area where there is the “expected” positive association between VDL density and higher rates of MH prescriptions.
1975 Ordnance Survey (top) and 2012 GoogleEarth view (bottom – looking roughly northwest) of a former oil storage/filling station near Drumchapel South. VDL is outlined in red.

**Pilot Site 2,** near Drumchapel South (another PARDLI area), was used for oil storage, and became derelict between 1996 and 2000.

However, in contrast to Pilot Site 1, this area has a more modest local $R^2$ (0.37) and smaller magnitude VDL coefficient, suggesting a weaker relationship between VDL and MH prescriptions rates.
Conclusions

~ This study demonstrates an environmental health inequity re: distribution of VDL in Glasgow.

~ Bivariate correlation shows that populations in higher deprivation areas are typically exposed to higher densities of VDL.

~ Many deprived communities are disproportionately burdened with environmental impacts and psycho-social stressors associated with this land use.

~ Regression analyses show the association between VDL density and elevated rates of MH prescriptions, inferring that VDL has implications for MH.
Conclusions

~ The spatial non-stationarity shown in the GWR may be explained by specific characteristics of the VDL, such as de facto use and visual impact. This can be further explored by qualitative analyses.

~ By combining quantitative and qualitative approaches in this manner, additional insights can be obtained, enabling the generation of new hypotheses.

~ The relationship between VDL density and MH prescription rates is not necessarily a causal one, but the strong association between the two points to a good opportunity to transform neighborhoods’ VDL from a potential environmental stressor to a positive environmental benefit for the proximate populations.
“[A] society that allows such a pattern of coincidence [between poor populations and poor environment] to persist has failed to equally protect its citizens. This failure, itself, constitutes an environmental injustice. Whether the result of...putting economic profits over the health of people, or benign neglect, this disproportionate risk can and does lead to disastrous results.”