An analysis of the relationship between sociodemographic features and complaints of bed bug infestations at the population ward level in Toronto, Canada

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ABSTRACT

Studies have pointed toward a resurgence of bed bugs. Many of these studies have identified several determinants such as distant and intermediate sociodemographic factors, responsible for the resurgence of this prehistoric pest. In this retrospective descriptive study with ecological association, Social Determinants of Health approach and Descriptive Correlation Research framework were used for predicting and explaining those possible relationships between the selected sociodemographic features (independent variables), and the number of bed bug complaints in 2009 and 2010 by ward-level (dependent variables) in Toronto. Independent variables like apartment buildings with <5 storeys (Spearman's rho=0.555,p=0.006/rho=0.571,p=0.002), rental dwellings (rho=0.590,p<0.001/rho=0.623,p<0.001), multi-family households (rho=-0.405,p=0.002/rho=-0.421,p=0.002), and work (Pearson correlation: r=0.538,p<0.001/r=0.600,p<0.001) and non-work (r=0.652,p<0.001/r=0.648,p<0.001) trips by transit appeared to have a relationship with the number of complaints received in 2009 and 2010. The aforesaid independent variables were responsible for 16-43% of variation in the number of complaints. This study was able to demonstrate a statistical correlation between some of these sociodemographic features, and bed bug infestations reflected in the complaints received by Toronto Public Health. The results of this particular study are considered to be helpful in increasing community partnerships and leadership from Toronto Public Health in dealing with various bed bug-related issues.

Keywords: Bed bugs, bed bug complaints, bed bug infestations, City of Toronto, sociodemographic features,Toronto Public Health

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Introduction: Bed bug (*Cimex lectularius)* has been acknowledged as a human parasite for a significant number of years. Bed bug is usually a reddish brown, egg-shaped, wingless, flat, bloodsucking insect, which has a length of one to seven millimetres, and has a lifespan of four to twelve months (Chen & Copes, 2010; WHO, 2010; Hwang et al., 2005). This parasite is from the family of *Cimicidae* and lives exclusively on the blood of mammals including humans and rodents as well as birds associated with human activities such as chickens, and can survive for several months between meals (Chen & Copes, 2010; Goddard & deShazo, 2009). Another important fact is that bed bug infestations can go without detection for a long period of time, until the infestation is at its acute stage (Lee et al., 2008). In

List of Abbreviations:
DCR   : Descriptive Correlation Research
HBV   :Hepatitis B Virus
HIV   :Human Immunodeficiency Virus
SDH   :Social Determinants of Health
TB   :Tuberculosis
TPH   :Toronto Public Health

Glossary:

Apartment, detached duplex: refers to "one of two dwellings, located one above the other… may not be attached to other dwellings or buildings" (City of Toronto, 2011).

Apartment Buildings with >5 Storeys: refers to an "apartment… building that has five or more storeys - A dwelling unit in a high-rise apartment building which has five or more storeys" (City of Toronto, 2011).

Apartment Buildings with <5 Storeys: refers to an "apartment… building that has fewer than five storeys - A dwelling unit attached to other dwelling units, or other non-residential space in a building that has fewer than five storeys" (City of Toronto, 2011).

Dwelling Built between before 1946 & 1980: refers to "the period in time [i.e. between before 1946 and 1980] during which the building or dwelling was originally constructed" (City of Toronto, 2011).

Dwelling Built between 1981 & 2006: refers to "the period in time [i.e. between 1981 and 2006] during which the building or dwelling was originally constructed" (City of Toronto, 2011).

Family with Low-income Incidence: "is the proportion or percentage of economic families or persons not in economic families in a given classification below the low income after tax cut-offs. These prevalence rates are calculated from unrounded estimates of economic families and persons 15 years of age and over not in economic families" (City of Toronto, 2011).

Multiple-family Household: "is made up of two or more families occupying the same dwelling" (City of Toronto, 2011).

Non-work Trips by Transit: refer to "main means a person uses to travel between home and place of [non]-work by …public transit..." (City of Toronto, 2011).

Rented Dwelling: refers to "whether some member of the household… rents the dwelling…" (City of Toronto, 2011).

Work Trips by Transit: refer to "main means a person uses to travel between home and place of work by …public transit..." (City of Toronto, 2011).

Unemployment Rate: refer to "…a particular group (age, sex, marital status, geographic area, etc.) is the unemployed in that group, expressed as a percentage of the labour force in that group, in the week prior to enumeration" (City of Toronto, 2011).

recent years, the resurgence of bed bugs in many parts of the world, often resulting in severe infestations in densely-populated urban areas and a perception of government overlooking of the seriousness of infestations, have led to increased calls for action.

Bed bug's likely ability to harbor human diseases including Tuberculosis (TB), Human Immunodeficiency Virus (HIV) and Hepatitis B Virus (HBV), etc. have been well-documented (Goddard & deShazo, 2009; Richard et al., 2009). Although bed bugs have not been linked to disease transmission, their bites have been reported to lead to negative effects such as sleeplessness, mental distress and social stigma, as well as various clinical symptoms including secondary infections and allergic reactions (CDC & EPA, 2010; Eddy & Jones, 2011). Even in the absence of a confirmed case of bed bug transmitting diseases between humans, bed bugs have become a growing concern for many major cities like Toronto. Sociodemographic features of urban areas such as family, household/dwelling, tenure, income, building/structure, travel characteristic, location, etc. can influence the likelihood and severity of bed bug infestations (Eddy & Jones, 2011; Potter et al., 2011; Comack & Lyons, 2011; Reis, 2010; Harraca et al., 2010; Richards et al., 2009; Bonnefoy et al., 2008; Siljander, 2007; Harlan, 2006; Hwang et al., 2005; Gbakima et al., 2002). According to Wang and Wen (2011), densely-occupied inhabited areas with a high turnover of tenants and lack of building maintenance have permitted bed bugs to endure and thrive within many major cities like Toronto.

According to Toronto Public Health (TPH) officials, in 2003, public shelters in this city reported an increase of 50% in bed bug-related incidences (Harlan, 2006). In 2010, TPH received over 1,500 bed bug-related service requests, compared to a mere 147 in 2006 (Ayre, 2010). In addition, TPH observed a 44-fold increase for service requests over a period of five years between 2004 and 2009; while the Metro Toronto Tenants' Association also received an increasing number of bed bug complaints, which constituted 60% of all pest related complaints in 2008 (Toronto Bed Bug Project Steering Committee, 2008). A number of Canadian pest control companies provided a range of treatments for bed bug infestations, where 2002 buildings were treated in 2006; 5079 in 2007; and 6589 buildings in 2008 (Toronto Bed Bug Project Steering Committee, 2008). This research aimed to determine if a relationship existed between sociodemographic features and bed bug complaints as a public health concern, in order to identify if a need existed for building community

partnerships and increasing direction from TPH in dealing with numerous bed bug-related issues. The key objective of this study was to test for any correlation between the independent variables, i.e. sociodemographic features and dependent variables, i.e. bed bug complaints. The theoretical base for this research was the Social Determinants of Health (SDH) approach, which advocates for a holistic approach to the issues related to bed bugs, recognizes the harmful health effects resulting from bed bugs, and provides reasoning for the social determinants needing to be addressed in order to develop policies and procedures to deal with bed bug issues (Comack & Lyons, 2011). In-addition, the Descriptive Correlation Research (DCR) framework has been preferred as the theoretical framework to explore the possible relationships between identified variables from the literature review, and bed bug-related complaints received by TPH (Radhakrishna et al., 2007).

Materials and Methods: This was an analytical ecological study with non-experimental design involving various statistical analyses of the secondary data on the selected sociodemographic features like dwellings by structural type (including apartments that are detached duplex, apartment buildings with >5/<5 Storeys), tenure, period of construction, households by type (i.e. multiple-family), employment rate, income incidence, and work/non-work trips by transit. These independent variables were determined using data obtained from Toronto Ward Profiles representing all of Toronto's 44 electoral wards, derived from the Statistics Canada's 2006 Census Semi-Custom Profiles. The dependent variables were the number of bed bug complaints received in 2009 and 2010 by TPH.

The positivist approach was applied in this deductive research to investigate/examine if statistical or relative association(s) existed between the abovementioned dependent and independent variables, to provide an objective conclusion. Due to the secondary nature of the data with no personal identifying information, ethical approval was not required from the local authority, i.e. the City of Toronto. Conversely, the University of Liverpool – Ethics Review Committee has approved the proposal.

Results:
The findings resulted from the analyses of bivariate correlation, univariate and multivariate linear regression (Correlation Coefficient, Scatter plots, Linear Regression, etc.) showed no violation of normality, linearity or homoscedasticity.The determination of relationship(s) between the independent variables showing a statistically

significant correlation with dependent variables was necessary to disqualify multicollinearity.

The variables: 'work trips by transit', 'non-work trips by transit' and 'rented dwellings' had significant correlations. Their values were 0.762, 0.652 and 0.638 in 2009, and 0.762, 0.648 and 0.638 in 2010, respectively.

The multiple regression models showed R Square values of 0.549 for 2009 and 0.552 for 2010, which was capable of explaining 55% of the variance in the number of complaints in both 2009 and 2010. In addition, the outcomes of these models were statistically significant at $p<0.001$. Further, of the five statistically significant independent variables, 'non-work trips by transit' had the highest standardized coefficients Beta (0.581 at $p = 0.010$ for 2009 and 0.342 at $p = 0.115$ for 2010), suggesting that 'non-work trips by transit' contributed 9.3% and 3.2% to the rationalization of variance in the number of complaints for 2009 and 2010, respectively. Therefore, for every 1% rise in 'non-work trips by transit', there will be 0.6 and 0.3 increase in bed bug complaints.

The Kruskal-Wallis Test (KW = chi-square = 43.000) was applied and corrected for the existence of ties in the ranks of the data, where n = 44; chi-square = 43.000; df (degrees of freedom) = 43; and p = 0.471 (which was greater than the significance level of <0.05). From this finding, it was concluded that there was no significant difference among wards in terms of bed bug complaints in both 2009 and 2010.

Discussion: According to Reis (2010), the existing literature suggests bed bug infestations can be common in apartment complexes due to the nature of their construction (close connectedness of rooms and units), and our results seemed to support this where 'apartment buildings with <5 storeys' had a large positive, statistically significant correlation with the number of complaints in both 2009 and 2010.
The question that remains is: why is it then, apartments that are detached duplex and with >5 storeys were found to be statistically not significant in this particular research? Perhaps, this is because those apartments have better bed bugs remediation strategies put in place than those 'apartments with <5 storeys'. Richards et al. (2009) suggested that low-rise apartments may be generally associated with poor maintenance, which can be linked to a lack of awareness and/or effective management of bed bug infestations. It would appear so, as apartment buildings (regardless of the number of storeys) which are over-crowded with a poor sanitation (generally,

poor living conditions) and in need of structural maintenance (i.e. repair of cracks, loose flooring, etc.) can provide bed bugs with adequate conditions (i.e. tiny harborages in floor boards, wallpaper seams, etc.); ambient temperatures (i.e. between 28 and 32 degree Celsius); and an appropriate humidity level (i.e. 75% to 80%)) for bed bugs to flourish (Bonnefoy et al., 2008; Comack & Lyons, 2011; Gbakima et al., 2002; Harlan, 2006;).

'Rented dwellings' had a large positive, statistically s ignificant correlation with the number of complaints i n both 2009 and 2010, supporting the findings of Bon nefoy et al. (2008) that documented bed bug infestati ons as being everpresent in transient rental dwellings, wherein tenants may unintentionally transport bed bu gs and/or eggs with their belongings. Our results als o supported the observations of Eddy & Jones (2011) that a general trend of increasing the proportion of res idential rental units in major urban areas, which bring s with it an increased migration of renters into those u rban centers; therefore, increases the chance of bed b ug infestation.

Unlike the previous two sociodemographic features, 'multiple-family households' had a large negative and statistically significant correlation with the dependent variables in both 2009 and 2010. As also indicated by Reis (2010), this particular finding suggests that despite the fact that the residential dwellings are overcrowded, the flourishing of bed bugs is on the negative. The primary basis for the pre-study assumption of bed bugs thriving in multiple-family households was that bed bugs would have a large number of potential hosts in a relatively small range (Siljander, 2007; Reis, 2010). As this research did not support this assumption, it could be because in order to avoid the social stigma associated with bed bugs, families from these particular households may not report infestations to TPH, or these families may be taking their own remediation of bed bug infestations. Another possibility is that the addition of more people in close proximity may result in better overall sanitation, housekeeping, communication and access to information resulting in an inadvertent prevention of bed bugs, which is supported by Eddy and Jones (2011). Nevertheless, if infected, the application of bed bug control measures in multi-family households is more complicated compared to single-family households, due to there being an increased amount of belongings and opportunities to go undetected during treatment (Rossi & Jennings, 2010).

'Work trips by transit' and 'non-work trips by transit' had large positive, statistically significant correlations with the total number of complaints in both 2009 and 2010. This could be due to public transportation being a favorable medium for bed bug dispersal, increasing the likelihood of infestations, regardless of travelling purpose. Siljander (2007) and Reis (2010) identified clothing, luggage, and other belongings carried with us on public transportations (such as buses, trains, ships and airplanes) and moving vans as ways that bed bugs can be brought into our dwellings.

Conclusion: This study was able to use the SDH approach and DCR framework as the theoretical base to explore if statistical or relative association(s) existed between the increasing bed bug complaints, and the relationships were presented holistically. The most important conclusion of this study is that under the broad spectrum of public health, bed bugs must be acknowledged as a public health problem rather than as a mere nuisance. Other than the sociodemographic features used in this study, there are many other non-quantifiable determinants of bed bug infestations which can only be understood by the existing differences among cities and their populations; however, these differences were not within the scope of this project, and may be the subject of future research. Future study in this field may be designed to collect and analyse primary data.

References:
1. Ayre R (2010). Bed Bugs – An Emerging Public Health Issue? Toronto Public Health.
2. Bonnefoy X et al. (2008). Public Health Significance of Urban Pests. World Health Organization.
3. CDC, EPA (2010). Joint Statement on Bed Bug Control in the United States from the U.S. Centers for Disease Control and Prevention (CDC) and the U.S. Environmental Protection Agency (EPA). Atlanta: U.S. Department of Health and Human Services.
4. Chin H, Copes R (2010). A review on bed bugs: epidemiology, health effects, and surveillance activities. Ontario's Public Health Agency.
5. City of Toronto (2011). Options Paper for Establishing New Community Councils. City of Toronto.

6. City of Toronto (2011). Ward Profiles: Ward Profiles Summary. City of Toronto.

7. Comack E, Lyons J (2011). Bed Bugs: A Public Health Problem? Purple Paper: National Collaborating Centre for Infectious Diseases, 27.

8. Comack E, Lyons J (2011). What Happens When the Bed Bugs Do Bite? – The Social Impacts of a Bed Bug Infestation on Winnipeg's Inner-City Residents. Canadian Center for Policy Alternatives-Manitoba (CCPA-MB).

9. Eddy CR, Jones SC (2011). Bed Bugs, Public Health, and Social Justice: Part 1, A Call to Action. Journal of Environmental Health, 73(8): 8-17.

10. Gbakima AA et al. (2002). High prevalence of bedbugs Cimex hemipterus and Cimex lectularis in camps for internally displace persons in Freetown, Sierra Leone: A pilot humanitarian investigation. WAJM, 21(4): 268-271.

11. Goddard J, deShazo R (2009). Bed Bugs (Cimex lectularius) and Clinical Consequence of Their Bites. JAMA, 301(13): 1358-1366.

12. Harlan HJ (2006). Bed Bugs 101: the Basics of Cimex lectularis. American Entomologist, 52(2): 99-101.

13. Harraca V et al. (2010). Characterization of the Antennal Olfactory System of the Bed Bug (Cimex lectularius). Chem. Senses, 35: 195-204.

14. Hwang SW et al. (2005). Bed Bug Infestations in an Urban Environment. Emerging Infectious Diseases, 11(4): 533-538.

15. Lee IY et al. (2008). Reemergence of the bedbug Cimex lectularius in Seoul,Korea. Korean Journal of Parasitology, 46(4): 269-271.

16. Potter MF, Rosenberg B, Henriksen M (2011). Bugs without Borders – Executive Summary: Defining the Global Bed Bug Resurgence. The National Pest Management Association (NPMA) and the University of Kentucky.

17. Radhakrishna et al., (2007). Strategies for Linking Theoretical Framework and Research Types. Proceeding of the 2007 AAAE Research Conference, 34.

18. Reis MD (2010). An Evaluation of Bed Bug (Cimex lectularius L.) Host Location and Aggregation Behavior. Virginia Polytechnic Institute and State University.

19. Richards L et al. (2009). Are bed bug infestation on the increase within Greater London? Journal of Environmental Health Research, 9(1): 17-24.

20. Richard S et al. (2009). Detection of a new bacterium related to 'Candidatus Midichloria mitochondrii' in bed buds. European Society of Clinical Microbiology and Infectious Diseases, CMI, 15 (Suppl. 2): 84–85.

21. Rossi L, Jennings S (2010). Bed Bugs: A Public Health Problem in Need of a Collaborative Solution. Journal of Environmental Health, 72(8): 34-35.

22. Siljander ED (2007). Intraspecific Communication of the Common Bed bug Cimex lectularius Linnaeus (Hemiptera: Cimicidae). Simon Fraser University.

23. Toronto Bed Bug Project Steering Committee (2008). Bed Bugs in Toronto: Developing an Effective Response. WoodGreen Community Services.

24. Wang C, Wen X (2011). Bed Bug Infestations and Control Practices in China: Implications for Fighting the Global Bed Bug Resurgence. Insects, 2: 83-95.

25. Wang C et al. (2010). Characteristics of Cimex lectularius (Hemiptera: Cimicidae), Infestation and Dispersal in a High-Rise Apartment Building. Journal of Economic Entomology, 103(1): 172-177.

26. WHO (2010). Bedbugs, fleas, lice, ticks and mites: Ectoparasites that live on the body, in clothing and in beds. World Health Organization.