International Journal of Science and Healthcare Research
Vol.4; Issue: 2; April-June 2019
Website: www.ijshr.com
Original Research Article *ISSN: 2455-7587*

Geographic Variation of Public Health Data Collection Associated With Health Outcomes: Elevated Lung Cancer Mortality in a Medium-Sized City in Brazil

Heslley Machado Silva[1], Brenda Maria Oliveira Mendonça[2], Jayne Cristina Guimarães[3], Luciana Soares Rodrigues[4], Robert A. Michaels[5]

[1,2,3,4] University Center of Formiga/MG. UNIFOR/MG. Dr. Arnaldo de Senna Avenue, 328 - Água Vermelha. Formiga City. State of Minas Gerais. Brazil.
[5]RAM TRAC Corporation, 3100 Rosendale Road, Schenectady, NY 12309, USA.

Corresponding Author: Heslley Machado Silva

ABSTRACT

Background: Cancers collectively pose a major public health challenge globally. Lung cancer is among the most common and deadly cancer types, but its incidence and mortality rates in small- and medium-sized municipalities may be difficult to explain adequately where inadequate data collection hampers health studies.
Objective: to investigate lung cancer incidence and mortality in Formiga, a medium-sized municipality in south eastern Brazil.
Materials and Methods: Accordingly, we augmented limited available data from the Brazilian Government DATASUS database with interviews with 12 local physicians.
Results and Conclusions: Interviews revealed lung cancer mortality in Formiga significantly exceeding Brazil's national average reported in DATASUS. Lung cancer mortality of females likewise was elevated. Physicians suggested that tobacco use explains the elevated mortality. Available data and physician interviews, however, together failed to determine quantitatively whether excess lung cancer could be explained fully by elevated tobacco use in Formiga. More complete data collection and further research will be needed to explain adequately the incidence and mortality anomalies in the municipality as a whole, and among females in particular. In the current circumstance of limited data availability, such investigations inevitably must require additional, labor-intensive epidemiological approaches. Routine, thorough collection of public health data, and of lung cancer incidence and mortality data specifically, for municipalities of all sizes would improve cost effectiveness of public health endeavors.

Key words: lung cancer incidence, mortality, data collection, geographic variation, physician interviews

INTRODUCTION

Cancer is a growing health problem that is difficult to manage. Its global distribution is irregular, with incidence variation among continents, and regional variation among continental regions. Understanding lung cancer epidemiology requires explanation of these levels of variation. [1] Many studies evaluate lung cancer distribution by continent and region, but local variation also may have different explanations, such as exposures to specific potentially carcinogenic agents. Such variations in chemical exposure may be augmented by cultural factors, including behavioral, dietary, environmental, and other factors. [2]

Globally, in 2000 the number of new cancer cases was 5.3 million in males and 4.7 million in females. The number of deaths was 6.2 million, corresponding to 12 percent of all deaths on the planet, 3.5 million of which were in males and 2.7 million in females. The lower mortality among females most may be attributable to their more effective prevention and treatment behavior.

Lung cancer has been reported to be the most prevalent cancer globally, with 1.2

million new cases annually. [3] Its mortality also is very high, 1.1 million deaths per year, producing a 90-percent mortality rate. Several cancers likewise have high incidence globally but, among even these, lung cancer mortality is above the average. [1] In the European Union, as elsewhere, lung cancer has been reported to be the most likely type to be fatal. [4] An epidemiology study of Europeans likewise revealed association of mortality with education level, and a higher lung mortality rate in countries with a lower distribution of higher education attainment. [5] Finally, the incidence of lung cancer has been growing for decades. [6]

The above observations together justify according the highest public health priority to investigating the epidemiology of this unique cancer. Explaining the exceptionally high incidence of lung cancer is essential. Such understanding might enable public health policy makers to address effectively the causes of the high prevalence of lung cancer.

The National Cancer Institute of Brazil (INCA) estimated that the number of lung cancer cases per 100,000 people in the southeastern region of Brazil was 17,800 among males and 9,830 among females, rounded to estimated risks of 18 per 100,000 for males and 10 per 100,000 for females. In this region, lung cancer exhibited the second highest cancer incidence for males (21 per 100,000), and the fourth highest incidence for females, (11 per 100,000), in both cases higher than the national average. [7]

The biggest overall risk factor for cancer is smoking. An investigation conducted in 2008 by the Brazilian Institute of Geography and Statistics (IBGE) along with the National Cancer Institute (INCA) reported that the prevalence of smokers over 15 years of age was 17.2 percent, corresponding to 25 million people. The highest prevalence was found in the southern region, and the lowest in the central-west and southeast regions, respectively, 19 percent and 16.9 percent. [8] The smoking habit alone has been estimated to cause 21 percent of all neoplasm-related deaths globally. The percentage of smoking-related cancer deaths was higher in countries with high income (29 percent) than in low- and middle-income countries (18 percent), possibly due to lower prevalence of smoking history in these countries, especially among females. The number of cancer deaths attributable to cigarette smoking, however, has been reported to be higher in low- and middle-income countries such as Brazil (896,000 and 596,000 for males and females, respectively), producing the highest total number of deaths annually. [2]

An estimated 80 to 90 percent of the incidence of lung cancer has been associated with tobacco use. Smokers have been reported to exhibit 20 to 30 times the risk of developing lung cancer compared with non smokers and with smokers who smoked fewer than 100 cigarettes in the course of their lives. [9] In general, cigarette consumption in a country or region is linked to smoking rates. In countries with a long history of cigarette smoking, 90 percent of lung cancer cases in males have been associated with this habit. Further, the pattern of occurrence is strongly associated with the duration of cigarette smoking, and with passive exposure to cigarette smoke. [7] The literature clearly has established strong associations of smoking with lung, tracheal, and bronchial cancers. Smoking cessation has been strongly associated with mitigation of cancer risks. Such risk mitigation via smoking cessation has been associated with cancers of the lung, mouth, pharynx, larynx, esophagus, bladder, pancreas and kidneys . [6]

The relative influence of heredity and smoking in lung cancer causation is difficult to assess. A family history of lung cancer, however, has been reported to increase the risk of onset of the disease. Most notably, a family history of lung cancer appearance at an early age predicts an elevated incidence of early-age lung cancer among healthy members of the family.[7]

Epidemiological research identifies other factors that also may contribute to lung cancer risk. Obesity, second only to smoking as a cancer risk factor, recently has been associated with *reducing* lung cancer mortality through boosting the effectiveness of anticancer medications. [9] Factors associated with increasing the incidence of lung cancer include: exposure to radioactive radon gas, air pollution, asbestos, and uranium; repeated pulmonary infections such as tuberculosis; as well as excess of, and deficiency of, vitamin A. Occupational and environmental factors also may contribute to the lung cancer incidence, including passive smoking, certain types of air pollution (diesel and polycyclic aromatic hydrocarbons from cars and industries), and other types of ionizing radiation. [3,7]

In locations where lung cancer incidence exceeds that expected from smoking rates alone, significant additional factors are suggested. Indeed, the high incidence and variability of lung cancer globally indicates the importance of accounting for the full diversity of its contributing genetic, occupational, and environmental factors, beyond just smoking rates. Of great importance is the geographic variation of each of the contributing factors. Accomplishing this task will require routine, thorough public health data collection, including in big cities and also in small- and medium-sized cities, as well as in rural areas.

One highly potent chemical factor that evidently is highly relevant to lung cancer and also may be highly relevant in Brazil has been identified in the Village of Hoosick Falls, a small municipality in Rensselaer County in New York State. [10] That factor is perfluorooctanoic acid (PFOA) and related perfluoro-alkyl compounds (PFCs), most notably including perfluorooctane sulfonate (PFOS). PFOA is a ubiquitous, persistent, and bioaccumulative contaminant globally. [11] Its production in the U. S. has been banned, but much of its global production has been shifted to China. Sixty-six PFCs including PFOA were reported to be registered in the *Inventory of Existing Chemical Substances in China*. Approximately half of Chinese production was reported exported to Europe, Japan, and Brazil. [12,13]

PFOA is unusual in exerting toxic effects in the parts-per-trillion (ppt) range occupationally and environmentally. Its critical toxic effect (the effect exerted with least exposure) is immunosuppression. Immunosuppression compromises immune surveillance and thereby diminishes the body's ability to distinguish self vs. non-self cells, and its ability to identify and kill 'foreign' cells (including cancer cells). Most essentially, PFOA evidently is potent at elevating response to carcinogens such as cigarette smoke apart from any carcinogenic effect that they also may exert (PFOA also is a carcinogen, but as yet has not been implicated specifically in causation of lung cancer). Indeed, a survey of cancer incidence in Hoosick Falls suggests that elevation of lung cancer incidence constitutes an expected outcome of elevated PFOA exposure, even in the absence of lung carcinogenicity, mediated via suppression of immune surveillance among people who (inevitably) are exposed to other lung carcinogens.

Our current research seeks to estimate and analyze, among the main types of cancer, the incidence and mortality of lung cancer in the medium-sized city of Formiga in the state of Minas Gerais in southeastern Brazil. Although much research has addressed the incidence of cancer in large cities, states, and countries, [17] little comparable research has addressed small- and medium-sized cities. Our intent, therefore, is to use Formiga as a case study to suggest new avenues for future research to identify and explain anomalies in lung cancer incidence and mortality in small- and medium-sized cites generally. Such research may be invaluable toward taking effective, targeted preventive actions.

This research was supported by FAPEMIG (Research Support Foundation of Minas Gerais) and the CEPEP research nucleus of UNIFOR/MG (University Center of Formiga/MG).

MATERIALS AND METHODS

For the survey and analysis of the incidence of cancer in the municipality of Formiga we sought to use and cross-refer quantitative and qualitative approaches employing triangulation of methods.[14] Public municipal data were searched to quantify lung cancer incidence, prevalence, and mortality for later comparison with state and national data. Use of data available in the health system can be an invaluable, affordable resource, especially in countries with relatively low research funding. [15]

We found data deficiencies, requiring us also to augment the local cancer database. We did so by conducting semi-structured interviews with twelve physicians in Formiga. These physicians were chosen for their accessibility and their inclusion of cases of neoplasia in their clinical practices.

To visualize and compare data, several types of graphs were generated via Microsoft Excel. These enabled us to visualize the incidence and distribution of lung cancer in the municipality of Formiga/MG. We also used graphical presentation to compare local, regional, and national lung cancer distributions.

The Collective Subject Discourse method was used in analyzing interviews with physicians.[16] Interviews were conducted in a semi-structured manner, generating free discourse from predetermined questions. This interview format allowed physicians the freedom to speak about the complex theme of cancer in a fluid way. [17] Each interview with a physician included the following questions:

--I - In your experience as a physician, which cancer do you notice as being the most prevalent in the municipality? Aiming some parameters such as: age, sex, frequency of diagnosis, aggressiveness of cancer and recommended treatment.

--II - In your opinion, what are the possible reasons for the prevalence of this specific type of cancer in your municipality?

--III - In your view, what could be done to reduce this incidence?

--IV - In your perception is there any characteristic or behavior typical of this city that could lead to this prevalence?

--V - People often seek medical help when they are already sick. How might people's priority be shifted to preventative medical care?

--VI - On the topic of this interview, would you like to supplement with more information from your experience?

In implementing this methodology, we used a flow chart (Figure 1). We aggregated interview content into subject areas, and grouped similar interview responses toward producing a conversational format for physician responses. In this way we attempted to synthesize a general, valid, and enriched discourse in the subject area of each question.

The interviews were recorded, transcribed, and physicians' responses cross-referenced to the types of cancer mentioned, to the main reasons for their prevalence in the municipality of Formiga/MG, and to possible prevention strategies. Interview transcripts were coded to remove physician identifying information. The purpose of coding was to preserve physicians' privacy and avoid possible conflicts of interest and ethics.

We thus combined qualitative and quantitative approaches toward elucidating information about cancer, including incidence, in the municipality. This approach has been endorsed as being advantageous and feasible in the public health arena, [18,19] producing a broad scope of quantitative comparisons while also enriching such comparisons via the qualitative interview content. The combination of the two methods also enables data verification, and may suggest new lines of investigation.

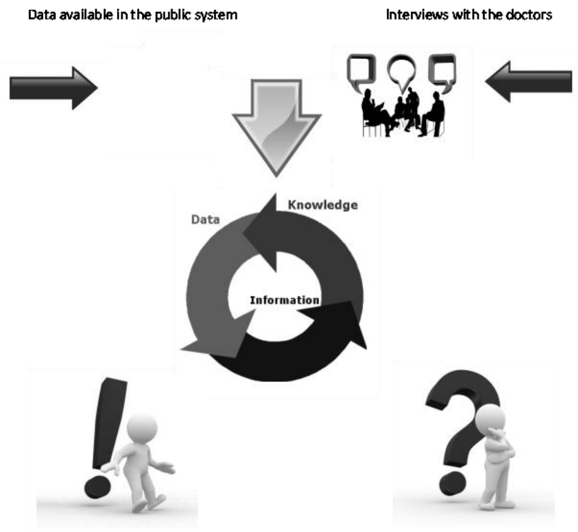

Figure 1: Synthesis of the research method used.

RESULTS

Data from DATASUS revealed that mortality from lung cancer stands out among other types in the municipality of Formiga/MG (Figure 2), consistent generally with other communities.

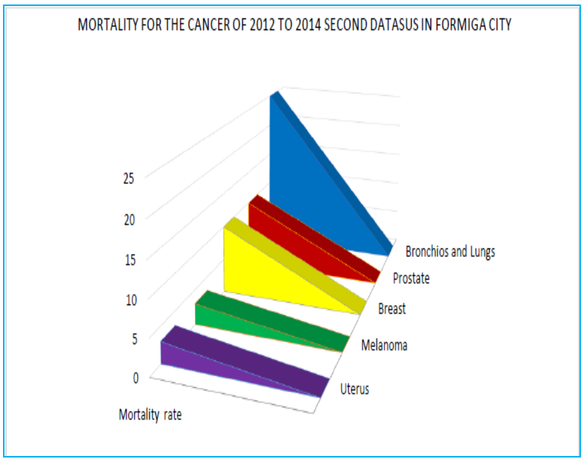

Figure 2: Deaths per 100,000 population of cancer types in the municipality of Formiga, 2012/2014. Source: DATASUS.

Lung cancer mortality rate in Formiga stood out relative to the Brazilian State of Minas Gerais and the nation (Figure 3).

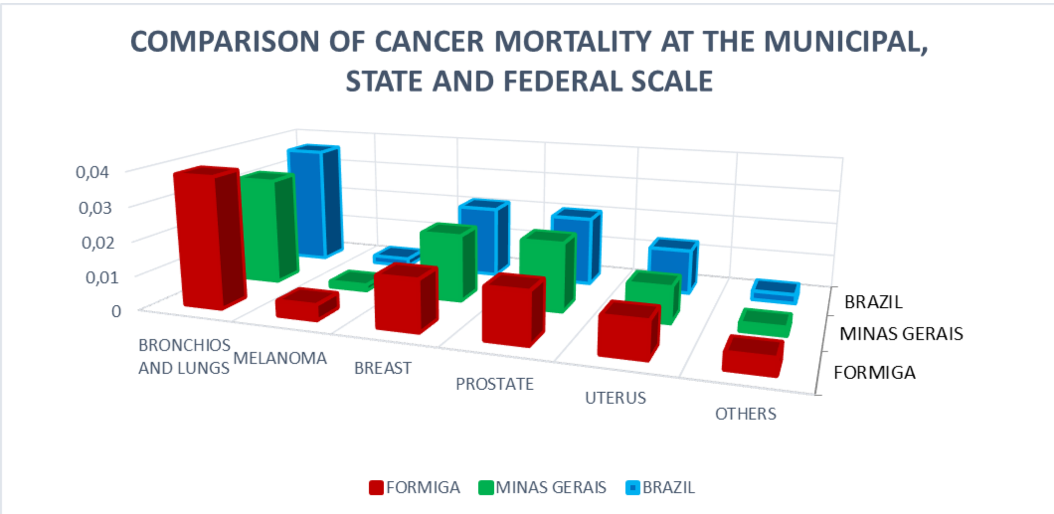

Figure 3: Deaths per 100,000 population from cancer compared to city, state and nation. Source: DATASUS.

Lung cancer mortality rates among females in Formiga (in 2005) likewise exceeded mortality rates among males as reported in DATASUS for Minas Gerais and the nation (Figure 4).

Lung cancer trends likewise revealed higher mortality among females than males. We used mortality data as a surrogate for incidence data, given the absence of the latter. Despite the high mortality rate in relation to the state of Minas Gerais and

Brazil, found in the DATASUS data, lung cancer was not mentioned by most physicians interviewed.

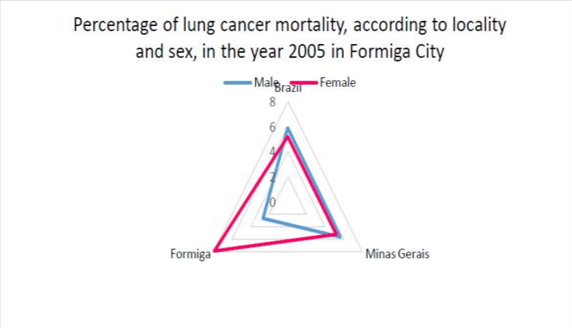

Figure 4: Lung Cancer Mortality (per 100,000 Population) compared by sex in 2005, Formiga, Minas Gerais and Brazil. Source: DATASUS.

From the question: *"In your experience as a physician what cancer do you notice as being the most prevalent in the municipality?"* 58 percent of the interviews did not mention this type of neoplasm as representative in this community. And again, despite its lethality in the municipality, lung cancer was not viewed as one of the most relevant compared to other cancer types in the collective discourse of physicians, in relation to the same question (Figure 5).

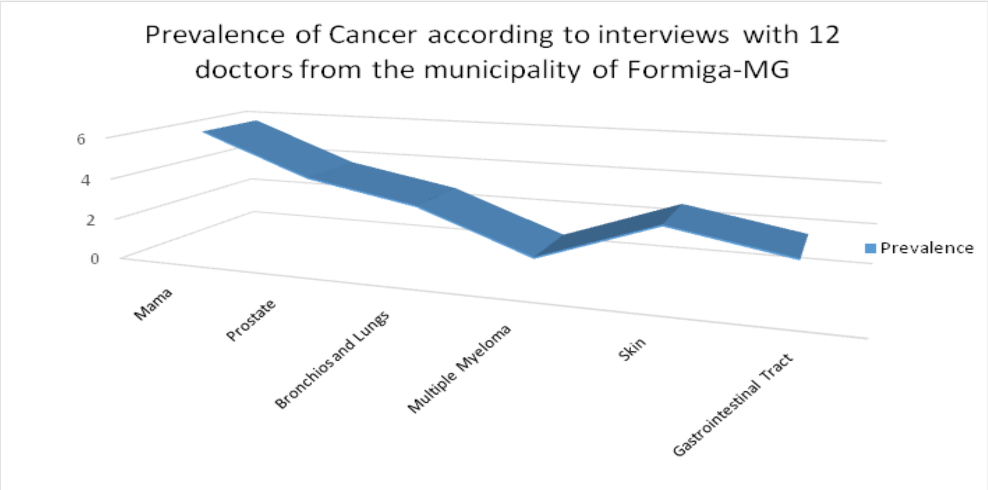

Figure 5: Prevalence of Cancer in the city of Formiga according to physicians. Source: Research (interviews with 12 physicians).

Interview responses eliciting proposed strategies for reducing the incidence of specific cancer types suggested physician prioritization of the lethality of the cancer type, which presumably encompasses both its incidence and its mortality rate in each physician's practice (Figure 6).

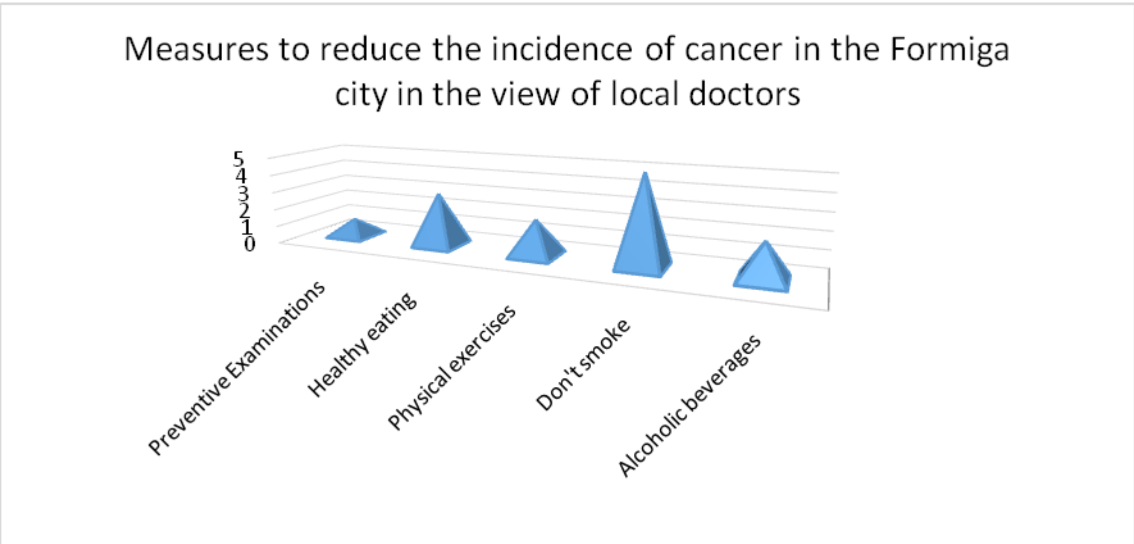

Figure 6: Ways to prevent cancer according to the physicians of the municipality. Source: Research (interviews with 12 physicians).

DISCUSSION

Our initially proposed investigation sought to analyze the incidence of cancer in the municipality of Formiga/MG, Brazil. Data availability locally, however, proved to constitute a significant limitation. Collection of local-scale data in addition to regional and national data should be increased as an economic approach to enhancing important local research and incorporating locality data to enhance the more holistic regional and national picture. This is especially important in the area of epidemiology.[15]

In the case of Formiga a data gap was evident in the search for cancer incidence information; it simply was found not to exist. We found that Brazil has a richness of epidemiology data relating to major cities, most notably capitals, states, and regions. [7] However, no comparable data source was found that could support our research, and this evidently is also the case for other small- and medium-sized municipalities in Brazil and very possibly beyond.

Elucidation of social inequalities in public health requires comparison of subpopulations. This in turn requires collection of public health data across demographic and geographical divisions. This necessity has been recognized also with respect to economic and life-span comparisons. [20]

Absence of needed epidemiology data relating to Formiga raises two questions. First, how can needed data be obtained? Second, why was Formiga and, by extension, perhaps other small- and medium-sized municipalities, initially omitted from relevant epidemiology data collection programs in Brazil?

To answer the first question, we searched for the most accessible databases at the municipal, state, and federal levels. None was found to include information about the incidence of any type of cancer in the municipality. Accordingly, an alternative strategy was developed, specifically, searching for a surrogate statistic that might be available from which lung cancer incidence might be inferred. The statistic that we found was mortality rate for numerous cancer types, including lung cancer. Our interviews with local physicians formed our second, hopefully corroborating source of information from which we sought to infer the incidence of lung cancer in the city.

The second question seeks to explain why small- and medium-sized municipalities might have been excluded from epidemiology data collection programs in Brazil. Such programs are essential as a direct link to data on the incidence of diseases, especially diseases that have high risks of occurring and of being fatal, and/or to require long, complex, and costly treatment. Often patients will seek treatment in other municipalities having greater clinical resources. As a result, mortality data may pertain to the treatment city rather than the residence city. Even the initial consultation that generated the diagnosis may have required travel to a different city. In that case, the incidence data likewise may pertain to the diagnosis city rather than to the residence city.

Lung cancers, as well as other cancers, may be influenced by exposure to environmental and occupational factors. Discrepancies between probable exposure locations vs. disease diagnosis, treatment, and death locations may complicate the epidemiological tasks of identifying associations of disease with environmental and occupational exposures, and of proving that associations are related causally rather than merely casually. This likewise was a problem with respect to investigation cancer rates in the Village of Hoosick Falls, and their possible association with PFCs released to the environment as a result of industrial activities locally. [10]

Complete health data resources also are requisite for documenting health care needs, and for devoting limited economic resources to establish health care facilities in relation to demonstrated need. As a result of data unavailability, and of health care facility unavailability, small- and medium-sized municipalities have exhibited little if any downward trend in cancer mortality rates, contrary to the reality in capital cities. Such unfavorable health outcomes presumably relate to delayed diagnosis and treatment.[21] In addition, in many relatively small cities, the Health Secretariats have insufficient financing, and therefore also insufficient professional expertise, required to conduct more general and more accurate surveys of health-related indexes. Efforts therefore should be made to acquire a broad range of epidemiology data in small- and medium-sized municipalities to facilitate cost-effective implementation of public health policy in historically underserved places.

Data gaps, most notably in DATASUS as discussed above, necessitated undertaking further work at greater expense for conducting physician interviews and cross-referencing interview data as needed to augment deficiencies in DATASUS. The methodology for this further work is depicted most generally in Figure 1, in which DATASUS and physician interviews must be reconciled to produce desired knowledge.

Results of cross-referencing are illustrated in Figures 2-6. These figures together demonstrate the importance of lung cancer whereas, in contrast, physician interviews ranked lung cancer as the third most frequent cancer behind breast and prostate cancers. What are the possible explanations for these very different rankings?

At the beginning of the 20th century lung cancer was less common, or less commonly diagnosed, but its incidence grew rapidly,[22] becoming the most common and deadly neoplasia globally, affecting males more than females. The high mortality of lung cancer found in Formiga City therefore is unsurprising. That physician interviews did not appropriately place lung cancer in the highest tier of importance in their clinical practices was surprising.

The explanation may be that lung neoplasm is normally perceived in advanced stages, as its early symptoms may be confused with more mundane conditions, such as bronchitis. Because of this, diagnosis and treatment of lung cancer tend to be delayed, drastically increasing its mortality rate. Lung cancer therefore has become one of the leading causes of preventable death in the late twentieth century. [7] This potential for prevention, however, has been realized to a greater degree in developed countries, where five-year survival has been reported to range from 13 to 20 percent. In developing countries, including Brazil, five-year survival was reported to be only 12 percent.

Mean lung cancer survival time from detection to death is measured in months. Smokers tend to die more quickly than former smokers, and never-smokers tend to survive longer than both. This suggests that high Lung cancer mortality rates in Formiga City may be related to a high smoking rate in the city. [23] Association of lung cancer with only short-term survival reasonably may be expected to reduce physician experience with it in their practices, for example relative to breast and prostate cancer.

Lung cancer patients diagnosed late, during advanced stages, tend to seek treatment at centers in big cities, and to exhibit low survival rates and short survival times. In contrast, early detection, in Stage I for example, produces significantly greater life expectancy - almost 90 percent up to 10 years - which is a survival rate comparable to that of other neoplasms. Dramatically greater survival time associated with early diagnosis of cancer, especially lung cancer, illustrates the importance of adopting public health policies, and making public health expenditures, that together assure universal, timely access to adequate medical facilities and care. [24]

As Figure 4 shows, lung cancer mortality rates in the State of Minas Gerais and in Brazil nationally were approximately equal. For both males and females, lung cancer mortality rates were approximately six percent of total cancer mortality. In contrast, in Formiga, lung cancer mortality for females was significantly higher, and for males significantly lower, than in the State of Minas Gerais and in Brazil nationally. Indeed, annual trends suggest that, despite variation of lung cancer mortality rates over a period of 15 years (2000 o 2015), the year 2005 shown in Figure 4 was unexceptional. The disparities highlighted in Figure 4 therefore deserve further investigation and explanation.

Lung cancer is more common among males, as is its most common cause: smoking. The difference between smoking rates among males and females has been narrowed in recent years as a result of increased smoking rates among females, and possibly also decreased rates among males.[22] A related issue is increase in the prevalence of smoking among female adolescents in some countries. [25] To illustrate the disparity of this female mortality in 2005, Figure 4 shows a higher mortality among females in Formiga/MG. The year 2005 shows a large gender difference in the number of lung cancer deaths. To determine whether or not the year 2005 was exceptional, we also looked at lung cancer mortality by year. Female death rates from lung cancer have been relatively high over the 16-year reporting period, from 2000 to 2015.

Comparable data from the United States may help explain the observed high female lung cancer mortality in Formiga. Whereas the incidence of this type of cancer is stabilizing among males in the US, it continues to increase among females. Public health outreach has aimed at reducing tobacco use in both genders, beginning at an early age. The response of females has been sluggish, given emerging freedom of females to emulate behaviors once reserved primarily for males.

Even so, the observed difference in lung cancer mortality rates by gender remains difficult to explain. Biochemical and epidemiological studies have shown different susceptibility of males and females to carcinogenic agents produced by cigarette smoking. Studies of the US population have revealed a higher level of vulnerability among females to all forms of exposure to tobacco smoke. [26]

Data on the incidence of lung cancer in China may suggest further lines of investigation toward explaining the observed gender difference in lung cancer mortality in Formiga, beyond smoking rates alone. In a large study in Shanghai, China, tobacco again was the most important lung cancer risk factor, but only a quarter of diagnosed cases were related to smoking. Most patients with lung adenocarcinoma, for example, had never smoked. Hormonal factors were striking for lung adenocarcinoma. Women experiencing late menopause exhibited three times the risk compared with other women.

The Chinese research also revealed that cooking may have exposed females differentially to mutagenic aerosols generated by cooking, and significantly increased their risk of eye irritation and lung cancer.[27] The cooking aerosols may have constituted a risk factor comparable to cigarette smoke, elevating female lung cancer rates in Shanghai. In multiple countries, elevated risks to females engaged in food preparation were reported independent of their smoking statu. [28] Households were found to be major sites of exposure to secondhand smoke for females and children. [25] These findings likewise might be relevant in Brazil.

Additional factors may be relevant to explaining elevated lung cancer prevalence in females. [29] These include family history, markers of susceptibility, previous lung diseases, environmental factors, and air pollution. Finally, lifestyle factors may be relevant, such as body weight, physical activity, menstrual factors, and reproductive factors (such as use of exogenous hormones). Such factors are important to study toward elucidating the high lung cancer incidence among females in Formiga, especially given that females generally are perceived as a low incidence group for lung cancer in Latin America. [29]

Although the ultimate explanation of female vs. male lung cancer incidence and mortality in Formiga remains elusive, one factor that is certainly important is relative smoking rates. Smoking rates among females in Formiga clearly must be above average, and together with greater female susceptibility to carcinogens generated by smoking, [26] must contribute to the overall picture significantly. Further investigation is necessary, focusing upon local behavioral factors and/or peculiar local characteristics.

The issue of lung cancer prevention is closely related to that of lung cancer causation: mitigating the causes reasonably would be expected to mitigate the incidence. These related issues were informed exclusively by physician interviews, as they were not amenable to data collection on the local, state, or national scale. Several physician statements, reflected in Figure 7, are worth highlighting here. Physician number 2, for example, reported that "2 or 3 lung cancer cases per month", a very high incidence for a municipality with just under 70,000 inhabitants. This same physician attributed this high incidence to the high smoking rate in Formiga. This perception was reinforced by physician 12, who referred to "the high number of smokers in the city." Physician number 8 looked beyond smoking as a possible explanation for the statistical elevation of lung cancer incidence, referring to "exposure to chemical agents in companies."

Lung cancer prevention must be approached in multiple ways. These include use of technologies for early detection, but this approach may have limited applicability in small- and medium-sized cities for the foreseeable future. Sputum cytology exams and chest radiographs are likewise not considered to be viable in small cities. Indeed, frequent radiographs may be harmful. [2] Therefore, once again it is urgent to find ways for this early detection that can be implemented in small and medium-sized municipalities.

Early diagnoses may be the best approach to increasing survival rates and survival durations, and should be increased. Implementing it, however, will be costly and technologically difficult to achieve, especially in resource-limited small- and medium-sized cities and in rural areas. A more promising and cost-effective approach to combating lung cancer is prevention. Prevention is feasible and economically viable for small and medium-sized cities, even where available economic and public health resources are scarce. To be successful, prevention will require major endeavors to combat smoking, as well as investigations into other causative agents. [3]

CONCLUSIONS

Epidemiological research in medium-sized municipalities in developing countries is a challenge, limited by data availability. We overcame this problem, at least partially, while investigating cancer incidence and mortality in the medium-sized city of Formiga in the state of Minas Gerais in southeastern Brazil. We circumvented the data limitation problem by using combined methodologies, focusing on available data at the state and national scale, and on interviews with local physicians to develop data at the municipal scale. In Formiga, lung cancer exhibited the highest incidence and mortality rates among cancers that we studied, and was generally elevated relative to the State of Minas Gerais and the nation. Incidence was especially high among females.

Interviews revealed physician priorities at variance with priorities implied by available state and national data. Inadequacy of medical facilities and expertise locally resulted in late cancer diagnosis and, in the case of lung cancer, greatly reduced survival rates and durations. Discrepancies between probable locations of exposure to causative agents vs. lung cancer diagnosis, treatment, and death locations complicates the epidemiological tasks of identifying associations of disease with environmental and occupational exposures, and of determining whether associations are related causally rather than merely casually. Deficiencies in the DATUSUS database suggest the need for further investigations into environmental habits, behaviors and factors that might explain locally high lung cancer incidence and mortality rates, as observed in Formiga.

REFERENCES

1. Maxwell Parkin, D., Bray, F., Ferlay, J. & Pisani, P. Estimating the world cancer burden: Globocan 2000. *Int. J. Cancer* 94, 153–156 (2001).
2. Danaei, G., Vander Hoorn, S., Lopez, A. D., Murray, C. J. & Ezzati, M. Causes of cancer in the world: comparative risk assessment of nine behavioural and environmental risk factors. *Lancet* 366, 1784–1793 (2005).
3. Malta, D. C. *et al.* Lung cancer, cancer of the trachea, and bronchial cancer: mortality trends in Brazil, 1980-2003*. *J. Bras. Pneumol.* 33, 536–543 (2007).
4. Bray, F., Tyczynski, J. E. & Parkin, D. M. Going up or coming down? The changing phases of the lung cancer epidemic from 1967 to 1999 in the 15 European Union countries. *Eur. J. Cancer* 40, 96–125 (2004).
5. Mackenbach, J. P. *et al.* Inequalities in lung cancer mortality by the educational level in 10 European populations. *Eur. J. Cancer* 40, 126–135 (2004).
6. Watson, W. L. & Conte, A. J. Lung cancer and smoking. *Am. J. Surg.* 89, 447–456 (1955).
7. Cordeiro, B. P. V., Felipe, C. F. P., Noronha, C. P., Ramos, D. N. & Cabral, E. S. C. *Estimativa 2010: Incidência de câncer no Brasil*. *Chemistry &* (2009). doi:CDD 616.994
8. Wünsch Filho, V., Mirra, A. P., López, R. V. M. & Antunes, L. F. Tabagismo e câncer no Brasil: evidências e perspectivas. *Rev. Bras. Epidemiol.* 13, 175–187 (2010).
9. Kaiser, J. Obesity gives unexpected boost to anticancer drugs. *Sci. (New York, NY)* 362, 734 (2018).
10. Michaels, R. A. Protecting Science and Public Health in Communities–PFOA and Possible Cancer Clusters in the Village of Hoosick Falls, Rensselaer County, New York. *Environ. Claims J.* 30, 58–70 (2018).
11. Michaels, R. A. Lessons learned from legacy contaminants of emerging concern: Perfluoroalkyl compounds (PFCs) in the Village of Hoosick Falls, Rensselaer County, New York. *Environ. Claims J.* 29, 4–48 (2017).
12. Ruisheng, Y. Preliminary Information on Risk Management Evaluation of PFOS's in China. *Nanxiaojie, Beijing Minist. Environ. Prot. China* (2008).
13. Webster, G. Potential human health effects of perfluorinated chemicals (PFCs). *Blood* 4, (2010).
14. de Souza Minayo, M. C., de Assis, S. G. & de Souza, E. R. *Avaliação por triangulação de métodos: abordagem de programas sociais*. (SciELO-Editora FIOCRUZ, 2005).
15. Kelman, C. W., Bass, A. J. & Holman, C. D. J. Research use of linked health data - A best practice protocol. *Aust. N. Z. J. Public Health* 26, 251–255 (2002).
16. Lefevre, F., Lefevre, A. M. C. & Marques, M. C. D. C. Discurso do sujeito coletivo, complexidade e auto-organização. *Cien. Saude Colet.* 14, 1193–1204 (2009).
17. Wilson, C. & Wilson, C. Chapter 2 – Semi-Structured Interviews. in *Interview Techniques for UX Practitioners* 23–41 (2014). doi:10.1016/B978-0-12-410393-1.00002-8
18. Morgan, D. L. Practical strategies for combining qualitative and quantitative methods: Applications to health research. *Qual. Health Res.* 8, 362–376 (1998).
19. Östlund, U., Kidd, L., Wengström, Y. & Rowa-Dewar, N. Combining qualitative and quantitative research within mixed method research designs: A methodological review. *Int. J. Nurs. Stud.* 48, 369–383 (2011).
20. van Raalte, A. A., Sasson, I. & Martikainen, P. The case for monitoring life-span inequality. *Science (80-.).* 362, 1002–1004 (2018).
21. Silva, G. A., Gamarra, C. J., Girianelli, V. R. & Valente, J. G. Cancer mortality trends in Brazilian state capitals and other municipalities between 1980 and 2006. *Rev. Saude Publica* 45, 1009–1018 (2011).
22. Organization, W. H. *World Cancer Report*. (IARC Press, 2003).
23. Pirker, R. *et al.* Prognostic factors in patients with advanced non-small cell lung cancer: Data from the phase III FLEX study. *Lung Cancer* 77, 376–382 (2012).

24. Canadian, T. *et al.* Survival of Patients with Stage I Lung Cancer Detected on CT Screening. *N. Engl. J. Med.* 2725–2732 (2006). doi:10.1056/NEJMoa1407426
25. Eriksen, M., Mackay, J., Schluger, N., Gomeshtapeh, F. I. & Drope, J. *The Tobacco Atlas, Atlanta, GA: The American Cancer Society*. (Inc, 2015).
26. Zang, E. A. & Wynder, E. L. Differences in Lung Cancer Risk Between Men and Women: Examination of the Evidence. *JNCI J. Natl. Cancer Inst.* 88, 183–192 (1996).
27. Jr, Y. G. W. J. B. W. Z. A. G. E. C. W. H. L. I. L. R. Z. J. F. F. Lung cancer among Chinese women. *Int. J. Cancer* 40, (1987).
28. Peng-Li Jia, Chao Zhang, Jia-Jie Yu, Chang Xu, Li Tang, X. S. The risk of lung cancer among cooking adults: a meta-analysis of 23 observational studies. *J. Cancer Res. Clin. Oncol.* 144, 229–240 (2018).
29. Wu, A. H. & Seow, A. Epidemiology of Lung Cancer in Women. *Women Heal.* 1191–1208 (2013). doi:10.1016/B978-0-12-384978-6.00079-0

How to cite this article: Silva. HM, Mendonça. B, Guimarães. JC. et al. Geographic variation of public health data collection associated with health outcomes: elevated lung cancer mortality in a medium-sized city in brazil. International Journal of Science & Healthcare Research. 2019; 4(2): 109-120.

******