The Health Impacts of Zoning Designations In Chicago

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Abstract

This research inquires about the extent of the impact of zoning on the health of neighborhood residents, utilizing Chicago as a focus. More specifically it seeks to answer to what extent and through what mechanisms do zoning designations influence health within neighborhoods in Chicago. Using data from the Chicago Department of Health, the research focuses on non-industrial zoning and utilizes spatial and statistical analysis tools in combination with a literature review to determine the most influential aspects of zoning on health. For this, low food access, overall health status, adult physical inactivity, poverty and psychological distress data were utilized as a stand-in for measures of health. The research also utilized Business, Commercial, Residential and Park and Open space zoning classifications as the focus of the zoning analysis. This paper explores the idea that because zoning shapes the built environment and that the built environment has an influence on health, zoning will have an impact on health and also addresses the influence that government decisions and politicization have on the built environment through zoning. Throughout this paper, it becomes clear that the total area occupied by residential zoning in a neighborhood impacts the level of physical activity. This relationship indicated that planning neighborhoods with a diversity of zoning that promote enough amenities within walking distance is essential to plan for healthier neighborhoods similar to the concept of 15-minute cities.

keywords
Spatial Planning, Zoning, GIS, Health, Physical Inactivity.

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0.1 Acknowledgments

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1. Introduction

Urban planners have historically been interested in developing ways to improve the health of urban populations through planning. Originally, one of the tools created for such a goal was zoning, a tool to promote healthy communities (Thornton et al., 2013). Zoning has been a common method utilized across countries that practice urban planning, where a city is divided into differently regulated sections dictating what is permissible to do and be built in the set area. Those spaces each are distinguished to serve a specific purpose such as housing or commerce and can go as specific as to limit the type of structure within those broad categories. For example, in Chicago, C1 is the zoning classification for a commercial district meant to allow for small commercial businesses with some auto-mobile business activity which also permits housing units at a ground level whereas C2 permits housing units but not at ground level (Chicago Zoning Ordinance Title 17-3, 2023). Zoning areas are typically divided by municipalities and are often re-classified through judicial processes at the request of land-owners, to facilitate development in America, in the case of Chicago zoning is controlled by Chicago's City Council. Despite its influence in the urban form, not enough importance has been given to the secondary impacts that this tool has, beyond its current intended practicality of shaping the urban space.

This thesis investigates how zoning distribution impacts the health of neighborhood residents. It examines how zoning interacts with land use and how the differences in the built environment impact the motivator and accessibility factors to leading a healthy life. Understanding that access to different resources and urban environment forms influences health is a key point to promoting the development of equitable living spaces where citizens can thrive regardless of which neighborhood they reside in. Also, providing insight on this aspect of zoning is an important part of contributing as a tool for decision-makers to make informed decisions. Measurings the influencing reason for the presence of healthy environments highlights part of what can change in a neighborhood and promotes

neighborhoods that host equal opportunities for residents to lead healthy lives. With that in mind, zoning is an integral tool within urban planning practices and urban planning issues are often wicked problems requiring multiple disciplines to fully understand. This means that many different problem-solving methods are necessary to be researched and understood to solve an individual issue, hence planners need to decide based on their values which aspects should be researched first and more in-depth over other less conventional approaches.

In recent years more attention and research has revolved around identifying the health impacts of Parks and Open Space and Industrial zoning districts while not much research has been performed on other types of zoning (Maantay, 2001). While investigating those aspects of zoning it is important to also study the other remaining aspects of zoning in order to not overlook pieces of the relationship between zoning as a whole and our living environment. Especially in 2023 recovering from a post-pandemic world where the idea of health in urban environments quickly shifts its focus to disease and obesity studies, other important health aspects influenced by our built environment become obscured.

Nevertheless in theory planners put a great amount of importance on the health of urban populations while in America and many other countries zoning decisions are often made with a limited amount of consideration to how they impact health due to conflicting priorities. A recurring goal of zoning decisions is the promotion of economic development without much mind to adverse health costs. One of the core reasons for this oversight is due to zoning decisions often being politicized (Thornton et al., 2013). That is because independently of the process that goes into a zoning decision, what ends up being delimitated as a desirable use is a direct result of external forces, as explained by Thornton, “Although zoning provides regulation, local market forces, politics, financing, cultural views of “appropriateness,” and enforcement greatly influence what is permitted, desired, and, ultimately, constructed” (Thornton et al., 2013). Furthermore, since the Second World War zoning has been approached as a form of commercial commodities in the United States, straying from the planning concepts intended during its creation (Nelson R.H., 1985). Essentially zoning changes have been sold off and used as bargaining chips between government authorities and land-owners through legal and underhanded means of generating profit. Hence due to these market forces and political interests neighborhoods find themselves with an uneven distribution of land uses significantly impacting equity (Maantay J., 2002).

Within this context, advancing current popular impactful approaches to shaping the urban form such as controlling gentrification and providing a disease-free environment are just as important and the findings of this research should be used along with other disciplines to pursue desirable development results. But in spite of that the focus of zoning decisions is still often politicized and favors economic development over building healthy and equitable communities and this research hopes to provide arguments to sway this tendency toward health-centric decisions (Thornton et al., 2013). As someone advising important decisions such as the landscape of a city having a strong basis of proof-based arguments to advise policymakers and strengthen community health-based decisions is essential.

This research also chose not to focus on epidemiology practices or industrial zoning designations as there is already a deep amount of research on these topics. To fill a knowledge gap this thesis seeks to highlight to what extent and through what mechanisms zoning designations influence health, utilizing Chicago neighborhoods as the subject of this study. Chicago was selected as the focus of this study due to easily available and extensive access to zoning, census, and relevant data from the city. Furthermore, its efficient record-keeping and the vast area containing 77 neighborhoods with unchanging boundaries through recent years provide a good sample size with a diverse number of locations to analyze (City of Chicago, 2018).

Physical and mental health are being investigated by measuring psychological distress, physical inactivity, self-reported health status, and food access variables, with poverty also being measured as a significant variable. The method used to study the influence of zoning on health variables is a statistical and spatially explicit comparison through the use of regression and correlation analyses with the aid of GIS (Geographical Information System Mapping) tools, where the presence of a zoning type is measured within a neighborhood and contrasted with the results of health-related surveys to attempt to identify relations between land-use aspects derived from zoning and a community's population average health. The comparison parameters were selected based on reviewed literature with previous research used to guide likely interactions between both aspects.

This paper's introduction presents the core concepts and logic behind the development of the thesis. The Literature Review deals with how the interaction between zoning and health has been investigated in recent studies and also provides insight into the nature of how zoning

decisions are made in America along with a historical view of how zoning research has been approached. The methodology section presents the steps of the analysis and its components, utilizing GIS spatial tools to handle the health and zoning data utilized within the analysis section. The Chicago section gives a brief introduction about the city. The Analysis section interprets a correlation analysis and a regression analysis leading into findings and discussion sub-sections identifying the relations between the results of the analysis and the information gathered during the thesis. Lastly, the conclusion highlights this thesis's core findings and final thoughts before providing a suggestion for future steps.

2. Research Objectives

This paper seeks to find an answer to how the distribution of zoning within a neighborhood impacts the health of citizens. Through this less explored lens of how zoning government decisions influence people's living environment and therefore impact their lives. During this research, it wishes to provide new insights into the influences of zoning on an aspect of neighborhood health mechanisms and acts as a new source of information for planners and inspiration for future research on this overlooked topic. With the intent of helping develop future cities, this thesis highlights the importance of considering zoning aspects in the planning of healthy communities and contributing to the development of healthy equitable neighborhoods.

2.1.Research Questions

To what extent and through what mechanisms do zoning designations influence health within neighborhoods in Chicago?

- What is the impact of zoning designations on the distribution of influencing health benefits in urban areas?
- How does zoning influence the physical activity levels, living habits, and overall health-influential decisions of residents?
- How does zoning influence land use?

3. Defining Terms

The main concepts of this thesis are health, zoning, built environment, land use and politicization. Stated below are the interpretations of the meaning of each concept with the intent of clarifying what are their intended meanings during this paper.

Health for this paper is being defined similarly to the World Health Organization's definition where "[h]ealth is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity." (WHO, 2023).

"In literature the term 'built environment' is often used to mean the human-made environment that may be subject to planning. It does not refer only to buildings and hard infrastructure but to all the physical elements that go to make up settlements, including greenspace" (Barton, 2009).

Land use and zoning are two similar tools and concepts but not the same:

Land use is a tool to regulate the use of land and its development. It aims to make the most of land use to the satisfaction of its occupants and environmental benefits.

Zoning is a tool that governments use to dictate land-use planning usage in an area. Zoning is a method of urban planning, where a city is divided into differently regulated zones, hence regulating land use. Zoning usually dictates the size and height of building limits, density, and building and infrastructure requirements (Blankenship, 2021).

GIS or geographic information systems are computer software capable of storing geographic information and displaying that information, being capable of interacting with visual displays of geographical data.

Politicization (politicized), can be interpreted as the act of having something influenced by a political matter or acting on something based on political ideologies.

4. Literature Review

The literature review follows a chronological insight into the recent research performed about the relationship between zoning and health, and land use and health. It consists of 6 sub-sections investigating different aspects of zoning. The American Zoning Influence and Health section examines the relationship between decision-makers interests and zoning decisions in the American context while acknowledging the potential applications in other countries' zoning practices. Build Environment and Zoning examines how zoning influences the built environment and its historical role in shaping this practice. Zoning And Land Use explains the relationship between zoning and land use and highlights the symbiotic relationship relationships between land use planning and public health. Zoning and Health addresses health equity concerns found in zoning practices. The Recent Research Findings section discusses recent studies on zoning, emphasizing the impact of Park & Open Space zoning, common research methods in the context of human health, and the link between residential density and mental health. Literature Review Analysis seeks to make the connection between zoning, urban planning, and public health by utilizing the arguments stated throughout the literature review.

4.1. American Zoning Influence and Health

This section explores the connection between the decision-makers interests and the decisions made toward zoning. It addresses the autonomy that those in charge of zoning have in the American zoning ruling process and the shortcomings that come with it. Furthermore, while this section is based fully on American examples of zoning practices a lot of other countries employ very similar development and governing methods. It is up to the reader to identify what aspects of the zoning process may overlap between these and different country processes.

In America, local government bodies control zoning and land use in one or many different jurisdictions. It is often the case that those in control of zoning favor political interests, sometimes leaving the negative effects of shaping a neighborhood overlooked. Zoning Law, Health, and Environmental Justice: What's the Connection? (Maantay, 2002) explored the influences of zoning and environmental justice in connection to health. Maantay opens her argument by stating that "Zoning laws determine what types of land uses and densities can occur on each property lot in a municipality, and therefore also govern the range

of potential environmental and health impacts resulting from the land use.", through this statement the logical assumption that zoning directly affects health through land use can be made. This journal highlights some of the conflicting interactions between politicization and zoning choices throughout recent political history using New York as a case study. She argues that zoning is meant to protect the public, but who the public is and what kind of protection is provided depends on the policymakers that made the zoning decision, and these decisions often overlook how zoning enables causes of disproportionate burdens. Typically politicians have other priorities such as protecting property values and keeping undesirable development from areas that often enable exclusionary practices. Practices such as restricting disadvantaged groups living locations, enabling predatory commercial development in neighborhoods and gentrification. Elected representatives may wish to not follow their electorate's suggestions when appointed because it can be quite easy to disregard individual wishes of neighborhoods in favor of others if there isn't consensus within the community. Neighborhoods can also suffer process un-equity due to inadequate access to information, bad meeting times, language barriers, not understanding technical terminology and not having equal access or influence on decisions. These issues and the limited ability of public participation in aiding equity translate into a barrier to influencing politicians decisions towards equitable and healthy zoning. This influence is best highlighted in the journal in this sentence:

"Zoning, in one fell swoop, took care of two of the major property value problems of the day in New York: the overbuilding of commercial space in bulk and height, so as to rob nearby structures of their light and air, and thereby reducing their value; and the encroachment of manufacturing land uses and associated people into exclusive shopping and residential districts.16 Thus, zoning preserved property values in two major ways, both of which aided zoning's covert connection to exclusion" (Maantay, 2002).

Zoning in other countries can work very similarly or differently from zoning in America. Countries like the Netherlands or Brazil utilize a very similar zoning system with slightly different re-zoning processes. For example, Brazil only forces a city to utilize zoning if it has over 20 thousand inhabitants and The Netherlands is much more lenient in its re-zoning processes where most of the zoning process is similar to the United States. Other countries apply only some aspects of zoning such as only enforcing the number of units or population density in a block and not the type of use.

4.2. Build Environment and Zoning

This section explores the relationship between zoning and the built environment. It retraces the origin of zoning's impact on public health which is linked to its historical purpose. Furthering into how the American government and governments with similar zoning practices utilize it to shape the built environment and how this practice is enforced. Additionally, it brings up arguments that indicate the direct limitations that come with planning when utilizing zoning.

Zoning classifications officially denominated zoning districts are commonly divided into categories where each has the intention to promote a specific type of development, those district categories are subdivided into purpose-focused categories. For example, a Business zoning district represented by the letter B will always be further specified as a B1, B2, B3, and so on in the *Zoning and Land Use Map*. In Chicago, these classifications are often further specified like B3-3 due to slight differences and concessions present in that area (City of Chicago, 2021).

Every plot of land within the city of Chicago is subject to the regulations respective to the zoning district they are within, where constructing something, indicating or using something in a manner outside permissible uses results in a violation of those laws. In Chicago, violations are subjected to penalties and remedies without a proper permit. Some of the actions the city takes upon a violation include withholding and revokement of permits, confiscation, and abatement of property, emission of fines of $500.00, and not more than $1,000.00 per violation (Chicago Zoning Ordinance Title 17-16, 2023). Hence not following zoning ordinations can be very damaging to anyone with significant stakes in a piece of property. Moreover, rezoning can be a lengthy, costly, and complicated process. Rezoning often incurs costs not only in the fees and in paying legal, planning, and real estate professionals to handle the rezoning process but also in bigger projects other costs may involve development-based demands from the municipality to fit the desired use. Arguably because government-based zoning change influences are limited to new developments and re-developments it could be said that there is a limited amount of impact that can be done through zoning. This is because existing infrastructures do not need to abide by new zoning changes in the United States unless renovated or with a change in purpose. In addition, often changing an owned land zoning designation requires approval from the owner.

When attempting to answer how zoning affects public health the following statements play a key role in understanding this relationship. As exacerbated in The Built Environment and Its Relationship to the Public's Health: Legal Framework, "The built environment significantly affects the public's health" (Perdue, Stone and Gostin, 2003), and historically zoning was created as a tool to promote health, safety, and the welfare of citizens (Thornton et al., 2013). Zoning and the built environment are different as highlighted in the defining terms section, but also directly correlated. Policies and laws meant to influence the built environment are often carried out through zoning ordinances, defining land configurations in districts, and therefore defining what is present in a neighborhood.

In Zoning for a Healthy Baltimore: A Health Impact Assessment of the Transform Baltimore Comprehensive Zoning Code Rewrite (Thornton et al., 2013) an in-depth explanation of the extent to which zoning influences the built environment is given. Thornton explains that in the United States cities use zoning to primarily control land redevelopment, where "[z]oning codes influence the built environment by regulating private land through the restriction of land uses and by governing building placement, size, and design." and that although it regulates what is permitted to be built in each region, ultimately it is market forces, cultural views, and politics that dictate how zoning is shaped. In practice, the effectiveness of zoning in deciding what is built is limited. This limitation is not only situational as explained earlier in this section but restricted by market forces. If an area is zoned for something it does not guarantee that it will be built up to all uses in its spectrum of allowable uses, nor all allowable uses will be present within a neighborhood. Hence there is an immeasurable amount of variation possible within any one zoning area. For example, two commercial zoning districts with the same possible classifications may either host a typical shopping mall, a parking lot, or a gun store (Thornton et al., 2013).

4.3. Zoning And Land Use

This section identifies the main points of studies that explain the relationship between zoning and land use and between land use and health. It indicates suggestions of how this relation can be optimized given the limited influence zoning has over land use and also identifies the research gap that this thesis seeks to address.

A significant number of works regarded industrial zoning as a significant and evident factor in the health of surrounding residents. In works such as Understanding the Role of Urban Design in Disease Spreading (Brizuela et al., 2021), the Chicago Health Impact Assessment Summary Report (Chicago Department of Public Health, 2022), and Zoning, Equity, and Public Health (Maantay, 2001), the impacts and influential reasons to which why industrial zoning when configured within close distance of residential neighborhoods significantly negatively impacts health is investigated. Some of these works also went into the influences of commercial zoning and infrastructure such as parks and factories. In them, it was found that the presence of a commercial zoning classification did improve or decrease the quality of life and health, but in a subjective way, whether it would be a positive or negative change. Unless the type of infrastructure built there is delimited, it was found that the impact on health is subject to the type of commercial building built in the location. For example, commercial zoning can enable the construction of a liquor store decreasing the health of surrounding residents and increasing violence, while the same designation is also capable of enabling the construction of a shopping strip improving the region.

Land Use Planning and Health and Well-being, Land Use Policy (Barton, 2009) states that there is a symbiotic relationship between land use planning and health, yet this has been dismissed until close to the date of the publication in 2009. Barton proposes that the division of departments such as health authorities and urban development departments has left a disconnection between the practices. When health departments concentrate on symptoms and diseases over promoting healthy environments health issues are bound to remain recurring. He highlights “diseases of advanced civilizations – such as cardio-vascular disease, diabetes, asthma and chronic depression – are associated with particular social and environmental conditions” (Barton, 2009), diseases directly influenced by the urban form and therefore likely to be improved by a change in land use. One such example of the urban environment impacting health can be seen in the quote below by Whitley and Prince:

“The quality of social networks is affected by people’s perception of the safety of their locality and their sense of belonging. One study of an inner London suburb found that residents experienced ‘time-space inequality’ as a consequence of crime and fear of crime, resulting in feelings of isolation and low self esteem” (Whitley and Prince, 2005).

4.4. Zoning and Health

This section explores the impact of zoning on health. It addresses health equity concerns found in zoning practices and the benefits of mixed-use development.

Pursuing Health Equity: Zoning - Codes and Public Health (Ransom, Amelia, Chris, and Kristin, 2011) expands on the concept that zoning policymakers by themselves are not the sole influencing part to shape the built environment. The overarching influence on what goes into a zoning district is not solely up to the local community and urban planners. By determining how close to residences businesses, services, and amenities are located and their access to nature and environmental benefits, while mindfully regulating other aspects controlled by zoning such as the proximity to alcohol and food. “For example, the purpose statement of the zoning code could more clearly articulate the role of public health in zoning, such as providing the opportunity for all communities to be healthy now and in the future. Walkability and access to daily services could be promoted by allowing more use areas (a combination of retail and residential uses) and design standards such as windows on the first floor of businesses and landscaping that make areas more attractive to pedestrians. Food access could be enhanced by reducing the required lot size for food stores, along farmers’ markets, community gardens, and urban agriculture throughout the city” (Ransom et al., 2011, p. 3). This study also promotes the idea that health equity disparities can be addressed by improving unequal economic, systemic, and social conditions with zoning plans being one of the tools through which health inequality can be addressed. Here it states that “studies supported an association between mixed-use developments and increased physical activity, 47–51 as well as decreased obesity and obesity-related illnesses”... “Mixed-use developments and TOD may create incentives for physical activity by providing amenities within walking distance and increasing access to daily services near transit stops” (Ransom et al., 2011). They conclude by expressing the importance of introducing the public health department's specialties as an advisor to zoning decision-making. Indicating how important it is to have zoning configurations that promote closeness between residential areas and amenities to incentivize healthy behaviors.

4.5. Recent Research Findings

This section addresses the most recent studies involving aspects of zoning related to health, accurate up to the year of 2023. It contains a section highlighting the role of Park & Open Space zoning designations in promoting exercise, social activity, and overall well-being. Followed by a description of the most commonly used research methods for research involving data and human health. Finishing by exploring the relationship between residential density and mental health from research performed in Denmark.

Some studies have also found within the last decade a correlation between green and blue spaces and health improvements. Biodiversity, Physical Health, and Climate Change: A Synthesis of Recent Evidence (Lindley et al., 2019) arrives at the conclusion that the presence of green and blue spaces encourages exercise and social cohesion, reduces obesity, and improves overall health. This can be attributed as a direct result of Park & Open Space zoning designations, furthermore, an individual partial health detriment or improvement can be directly correlated to the distance from these kinds of beneficial spaces.

Spatial dimensions of the influence of urban green-blue spaces on human health: A systematic review (Labib, Lindley, and Huck, 2020) generated insight into the most commonly used methods and variables for data-based urban research portraying human health. They found that “(a) availability, (b) accessibility, and (c) visibility” are good ways to further categorize the range of effectiveness of some infrastructures in the urban environment utilizing green space exposure as an example. It was also concluded that “The most common confounders were often sociodemographic data, including age, gender, education, income, ethnicity, race, marital status, employment status, and family size”, where “mental health studies utilized variables such as stressful life events, deprivation, poverty, crime rates, and social networks” (Labib et al., 2020).

The research whose methodology was most closely related to this paper, Higher depression risks in medium- than in high-density urban form across Denmark (Chen et al., 2023) provided insight into the interaction between residential density and mental health. Through utilizing a 3-dimensional mapping and statistical model the height and density of residential blocks were contrasted with the average mental wellness of its residents in Denmark. Their major findings for the purpose of this paper were that medium building

density was found to be the most likely to incite depression in residents independently of socioeconomic factors and high-rise with low density was found to be the one to promote the healthiest environment among high rise densities. Residents being close to lots of people gives a sense of community and increases social interaction, while green spaces and open-air are also good for mental health. Furthermore, sprawling suburbs seemed to host the worst environment for promoting mental health and well-being. Thus due to being in the middle individuals are deprived of a good amount of both open spaces and community. This recent discovery suggests that residential zoning decisions promote a direct impact on mental health depending on the density configuration.

4.6. Literature Review Analysis

This section aims to deliberate on the connection between zoning, urban development, and health, advocating for a multi-disciplinary approach to comprehending how zoning influences aspects of residents' well-being and future land use.

Montreece's research adds insight into the unrestricted nature of the process through which zoning influences the built environment. Even more, variability is introduced in the concepts approached in the build environment and zoning section, where not only there is the presence of the natural random nature of the free-market urban development within a zone as described by Barton, but also the deviation from what would be an ideal decision-making process with the purpose of favoring an area population's health (Barton, 2009). Complementarily Thornton and Maantay's research provides a picture of how this built environment development can further stray from a route that primarily benefits public health due to the influence of politics and the market in American cities (Thornton et al., 2013) (Maantay, 2002). Due to the nature of this interaction between external factors and the decision-making that surrounds zoning and the development made within it, the ideal urban shape cannot be reached merely by being aware of what it is. There is a need for a moving factor strong enough to push decision-makers to develop based on researched knowledge that would lead to healthy neighborhoods over decisions based on different priorities.

Throughout the found literature the relationships between built environment and health, and the relationship between government zoning decisions and the built environment have been found to be the focus of research. This paper aims to highlight the connection that

government policy, in this case, zoning, has with health by means of the built environment as a medium. Due to being a field scarcely explored through this perspective, there isn't much previous research done on this perspective. That is the case in recent literature, which has limited itself to one or two aspects of zoning not being able to provide a full picture of how zoning as a whole impacts health, while this paper hopes to provide a generalized view of the impacts of most zoning classifications on health. In addition, most papers have focused on how land use impacts the environment or how zoning impacts land use, but do not highlight the relation that zoning dictates land use. This is why it is important to understand that zoning is a prominent tool to promote future land-use changes.

Hence through presenting the previously shown research that different zoning classifications influence health but with a propensity to be affected by various surrounding factors such as neighborhood socioeconomic configurations and political influences a multi-disciplinary approach is necessary to promote the most healthy environment possible.

Due to the easily noticeable impacts of industrial compounds on health and the high popularity of blue and green spaces research, there has been quite a bit of research revolving around Industrial zoning and Parks and Open Spaces zoning performed since the year 2001. The focus of many of these studies surrounded air quality, pollution, mental health, and heat control. Unlike these works this research seeks to identify health impacts through a generalized lens, focusing on understanding how residents are able to make use of and also generally be affected by their surrounding built environment. For example, by identifying to what extent a neighborhood's population is likely to perform physical activities, it is possible to infer how friendly an environment(neighborhood) is towards physical activities. That is whether there are enough gyms, and spaces to run or perform sports, and if the built environment enables and incentivizes such habits that subsequently impact physical well-being. Measuring psychological distress in the context of this research is done so with the same concept, where the objective is to measure whether the environment dictated by zoning designations promotes mental well-being, be that through how being in that environment directly influences mental health and how it promotes activities that may better or worsen it. The measuring of food access is done with a slightly different purpose as lack of food affects both psychological and physical health. This aspect is measured with the purpose of identifying if the intended allowed uses within a neighborhood are facilitating access to basic needs. For instance, if a neighborhood lacks commercial or transportation infrastructure

it can be attributed to a scarcity of its allowed uses devoted to that infrastructure. Through this variable, it is possible to measure the presence of zoning designations that facilitate or do not affect food access, highlighting how zoning impacts this basic need. The choice to use overall health status, as reported by the population was to to identify an overview of how a population perceives their own health because it is important to understand the contentment of this stakeholder group which is the most directly affected by zoning differences in a health context. This variable presents a good measure of how satisfied a population is with the health-impacting conditions where they live.

5. Conceptual Framework

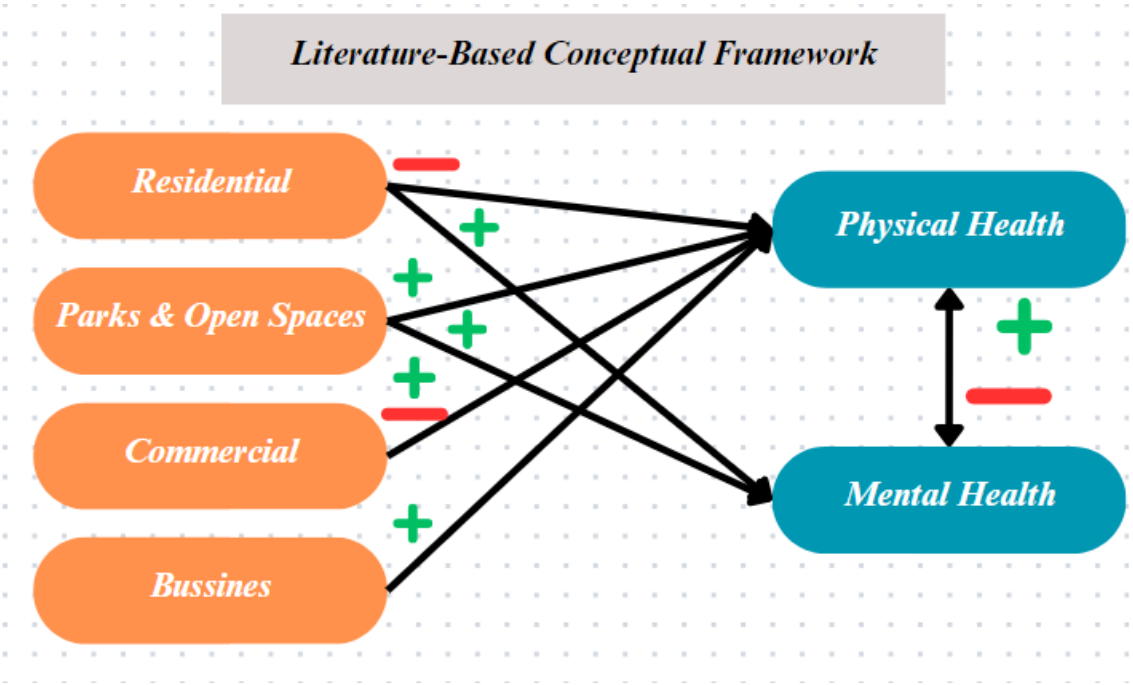


Image 1 Literature-Based Conceptual Framework

The *Literature-Based Conceptual Framework*, above contains a conceptual framework based on the identified relationship within the literature review section. In this, the independent variables are present on the left, and the dependent health variables are on the right. The means by which zoning influences health is through the mediating variables created by those zoning designations.

The mediating variable in this case is the presence of different types of infrastructure that dictate what is available to those who live in the proximity of those areas. The base of this research works under the assumption that because zoning dictates what infrastructure is or isn't present in a neighborhood the presence or lack thereof will influence the habits of individuals who live in those neighborhoods. This section provides a visual representation of the relationship between an increase or change in the zoning type and the resulting harm or benefit to health.

6. Methodology

6.1. Methodology Introduction

This methodology section consists of seven sections to explain the method taken to analyze the possible impacts of zoning on health based on that hypothesis. This Introduction section. A Variables Used section hosts an explanation of the variables utilized, their relevancy to the study, and conceptualization and operationalization. A Regression Model Testing Process, listing the methods used to ensure the proper testing was done for the analysis. A Mapping Tools section describing what software was used to perform the analysis and other aspects related to the use of those tools. A Data Analysis section going in-depth about the selected analysis methods. A Data Handling section detailing the steps taken with the data during the analysis in order to facilitate a re-creation of the study. Closing with the Limitations section that delimitates the most evident shortcomings of this research.

Chicago is famous for its history as a planned city and continues to be influenced nowadays by the Planning and Development department, making it a city extensively marked by urban planning. In addition to being one of the largest cities in the US and hosting 77 individual neighborhoods, it maintains a very good record-keeping method for all of its areas, whereas few other American cities keep such a good open database with information on each individual neighborhood. The city also contains a diverse amount of neighborhood configurations with Park & Open Space, Residential, Commercial, and Business districts present in all of its neighborhoods. Because of the reasons listed here, Chicago makes for an ideal place to measure the impacts of zoning planning decisions, thus having been chosen as the city of focus for this thesis.

All 77 Chicago neighborhoods were included during the analysis of this study due to tests indicating a lack of significant reason to split the sample into groups during the analysis. In order to streamline the research focus an initial assumption regarding the topic was made. With the purpose of answering to what extent and through what mechanisms zoning designations influence health within neighborhoods in Chicago, this thesis hypothesizes that there is a correlation between zoning designations and overall health, it works within the alternative hypotheses assumption that each independent zoning aspect can influence the dependent health variables. With the purpose of better identifying the best possible variables a

literature review of previous similar studies and other studies focusing on the land-use influence on health were performed prior to tackling the analysis. The literature review research also focused on identifying research that linked zoning or the built environment to health and the means through which health is directed and indirectly impacted by zoning. Then, evidence on how zoning has been recorded to interact with health and the built environment from the literature combined with spatial planning common knowledge to highlight the interaction between zoning and health, explaining the correlation between how zoning influences the built environment and how the built environment influences health.

A quantitative research strategy was chosen for this study due to the large amount of information needed to properly measure health in Chicago. Not only it would be a very long process to interview citizens, specialists, and government officials to identify a relation between health and zoning, but that piece would be based on opinion and unlikely to result in physical proof of the presence or absence of a connection between health and zoning. Correlation analysis and multiple linear regression analysis were the methods relied on to formulate the analysis and conclusion section in this thesis. Where correlation analysis method identified the individual relation between zoning variables and health variables independently of the other zoning relations and the regression analysis identified the interactions between all involved variables collectively. The importance of utilizing the linear multiple regression method is due to zoning designations not existing in a vacuum, their presence interacts with each other indirectly impacting what infrastructure combination is developed. A principle of real estate development practices is the analysis of such interactions where the presence of existing infrastructure incentivizes the construction of symbiotic developments. Meaning that new urban developments always take into account what other types of developments are already present in their proximities. Furthermore, the assignment of zoning type to an area strips it of any other zoning designations it previously held, hence zoning cannot be introduced to an area in an established city without excluding other zoning types.

For this research, Microsoft Excel and geographic information systems (GIS) played a central role in the handling of data. GIS mapping allowed for a visual representation of Chicago’s neighborhoods' health statuses, facilitated the translation of spatial data into measurable numeric values and facilitated the initial highlight of discrepancies between neighborhoods for analysis purposes. The choice to use GIS is further explained later in the

Spatial Analysis sections of this paper. ArcGIS and QGIS were the programs used throughout this project due to their versatility.

6.2. Variables Utilized

To make health measurable the concept was divided into two categories, physical health, which is the state of physical well-being, and mental health represented by the measure of psychological well-being of perceived health. Psychological health was selected in addition to physical health as a measure of focus because of how much it affects the functioning, well-being and function of individuals, having a significant impact on daily life. Within the concepts of each category, the mediating variables selected for this thesis were based on three key factors.

1. Firstly the data selected was required to be openly available in a neighborhood-sorted format and portray the period between the years 2019 and 2022.
2. Secondly, a selection was made of the variables that are most commonly agreed to be directly impacted by changes in the urban form as a result of land-use planning, hence affected by zoning delimitations.
3. Thirdly, a further selection and removal of qualified overlapping and similar variables were performed in favor of variables that best represented one or both intended aspects of health. Furthermore, data sets with a percentage rate representation were selected to better represent a neighborhood average experience regardless of population size and also facilitate an easier comparison between locations. Similarly, the majority of the data selected was from the years 2021-2022 to best represent the impact of current practices and avoid irregular data from the pandemic lockdowns. This selection was done this way to ensure that the health variables selected were the most likely to provide relevant correlation when measuring differences in the built environment.

During the analysis, the health data (dependent variables), were identified and contrasted with the predominant presence of a zoning denomination (independent variables) within each analyzed neighborhood to attempt to identify a correlation between the excess or lack of a zoning type and the amount present of measured health variables. This measure was made with the concept that the built environment acts as a mediating variable influenced by

the independent zoning variables to influence the dependent health variables. The dependent health variables at its source in The Healthy Chicago Survey were measured in a ratio format a percentage of the eligible measurable population within a neighborhood. The independent zoning classification variables were converted from polygon-shaped areas into a numerical representation and measured in a ratio format as a percentage of the total area occupied within a neighborhood in comparison to its total available area.

Health data for this study was sourced from Chicago Health Atlas (Chicago Department of Public Health and PHAME Center, 2023), which was selected as the data source due to being the most reliable government-collected health data website in Chicago. This data was sourced from the United States Census (https://www.census.gov/en.html) and The Healthy Chicago Survey (Chicago Department of Public Health, n.d.), a yearly survey performed by the Chicago Department of Health. The survey utilized a random selection method, with phone calls and letter questionaries for adults who are 18 or older which in 2020 changed to a web and paper survey method. It is important to also highlight that random surveys are likely to have results with slightly inaccurate data due to the human nature of lying (e.g.; lying due to socially difficult questions such as physical activity or mental health in a subconscious attempt to portray a better self-image) and the unpredictable nature of the selection process. A selection of variables that reliably represent health is only possible due to the efficient data collection in large amounts performed within the city of Chicago that ensures more accurate results. Government data tends to be highly reliable due to the large reach, time effectuated, and funding the data collection process has access to. By having access to a wide number of participants Chicago Health Atlas circumvents the biggest barriers to survey-based data collection which are low response rates and incomplete responses. Although having little to no access to some demographics such as the homeless and those without electronics is a drawback. Still, this method has more limitations, while the data collected represents a close picture of the health status from where it was taken there are some circumstances that may skew the resulting data set, those being the amount of resources invested in the survey and the limited survey method diminishing the pool of responses for accurate measurement of the population. The survey method of phone calls was the primary data collection method eliminating a significant amount of individuals from the survey who either cannot answer a phone call or chose not to do so. A similar critique can be applied to the online collection where only those who choose to answer the survey consist of its sample range. “The Healthy Chicago Survey (HCS) is an annual survey of non-institutionalized

adults aged 18 years and older living in Chicago. It was launched in 2014 by the Chicago Department of Public Health (CDPH) to better understand the health and experiences of Chicagoans." (Chicago Department of Public Health and PHAME Center, 2023).

The health variable information below is displayed in the following format:

- ➔ Variable category (variable measure format) years through which it was collected;
  - ◆ Which part of the population was the data collected from according to the Chicago Health Atlas?
  - ◆ Variable relation to health.
  - ◆ How it interacts with the built environment.

1. Moderate or serious psychological distress rate (% of adults), 2021-2022;
   - 1.1. Estimated percent of adults who were classified as having any psychological distress (Kessler 6 score of 5 or more) based on how often they felt nervous, hopeless, restless or fidgety, depressed, worthless, or that everything was an effort in the past 30 days.
   - 1.2. The psychological distress rate of a neighborhood portrays a good picture of its resident's mental health and is being used to identify mental health.
   - 1.3. Open space, green spaces, access to social centers, neighborhood beauty, and other urban aspects have been found to directly influence mental health.
2. Adult physical inactivity rate (% of adults), 2021-2022;
   - 2.1. Percent of adults who reported that they did not participate in any physical activities or exercises in the past month.
   - 2.2. Physical activity significantly influences physical health and is heavily impacted by the urban form. Therefore this variable is being used to measure physical health.
   - 2.3. The built environment dictates where an individual is able to exercise and how the environment is shaped may promote more or less physical exercise, for example, through the presence of gyms and parks or lack thereof.
3. Overall health status (% of adults), 2021-2022;
   - 3.1. Percent of adults who reported that their overall health is good, very good, or excellent.
   - 3.2. A self-reported measure of health is important to highlight the quality of life and health in accordance with how residents view it and acts as a measure of

physical health as it tends to be how individuals think of health when asked about their overall health.

3.3. Because this study attempts to measure the connection between health and the environment, it is necessary that a variable representing health as a whole is included.

4. Low food access (% of residents), 2019;
   4.1. Percent of residents who have low access to food, defined solely by distance: further than 1/2 mile from the nearest supermarket in an urban area, or further than 10 miles in a rural area.
   4.2. Low access to food and healthy food is detrimental to both physical and mental health and therefore can be used to measure both.
   4.3. Zoning shapes access to food by controlling the permissible presence of spaces where the sale of food is done.
5. Poverty rate (% of residents), 2017-2021;
   5.1. Percent of residents in families that are in poverty (below the Federal Poverty Level).
   5.2. Poverty influences all other variables to a state that requires its own category and is not quantified as a measure of health by itself. Although it is safe to assume that poverty is likely to lead to ill health.
   5.3. The built environment heavily influences poverty as it controls what opportunities for jobs are available and directly influences the costs of goods and necessities.

The independent zoning variables analyzed were retrieved from the City of Chicago's Data Portal (City of Chicago, 2018) in reference with a zoning districts boundaries map form. Their category and sub-category definitions and information can be found in the American Legal Publishing Archives under the Chicago Zoning Ordinance Title 17. For the purposes of this study, the zoning variables were measured by a percentage of the area within each neighborhood they occupied. If for example there were 3 zoning areas marked for business within neighborhood A which occupied 2%, 5% and 5.15% of the total area within neighborhood A, the Business variable assigned to neighborhood A would equal 12.15%. Due to the lack of sufficient presence for the purposes of analysis within Chicago the Downtown Mixed, Downtown Core, Downtown Residential, Downtown Service and Transportation zoning were not included in the final analysis. Furthermore, Planned Development, Planned

Manufacturing, and Manufacturing zoning data were included and utilized during the analysis but not investigated further during the results due to portraying an aspect of zoning that was not the intended focus of this research.

The following list describes the allowed uses within each zoning district type and some of their relationship to urban factors that influence health:

1. Business;
    1.1. Are capable of containing retail, service, and commercial uses with a more walkable configuration.
    1.2. Dictates access to food and basic needs hence influencing health.
    1.3. Promotes better mental health by providing facilities and locations that cause stress reduction and promotes better physical health by providing an incentive to commute by foot with enough proximity.
    1.4. Promotes worse health by enabling bad habits through the presence of infrastructure such as gun shops and liquor stores.
2. Commercial;
    2.1. It is similar to business zones with some different sub-classifications, tending to promote higher-traffic areas with more vehicle-oriented commerce.
    2.2. Promotes better mental health by providing facilities and locations that cause stress reduction and promotes better physical health by providing an incentive to commute by foot with enough proximity.
    2.3. Promotes worse health by enabling bad habits through the presence of infrastructure such as gun shops and liquor stores.
3. Residential;
    3.1. Residential districts have the intent of promoting housing while allowing for some other compatible non-residential uses.
    3.2. Residential density has been shown to impact mental health. High density was found to be beneficial when compared to medium-density residential. (T. Karen et al., 2023).
4. Downtown Mixed;
    4.1. “Intended to accommodate office, commercial, public, institutional and residential development” (Chicago Zoning Ordinance Title 17, 2023).

4.2. Contains health-influencing facts of both residential and commercial zoning designations.

4.3. Promotes high-density areas beneficial to mental health and offers easy access to services.

5. Downtown Core;
    5.1. Contains high-density offices and employment.
6. Downtown Residential;
    6.1. Promotes high-density residential and hosts some small-scale commercial at street level.
7. Downtown Service;
    7.1. Accommodates commercial and service businesses that have the function of supporting the livelihood of other businesses and resident needs. For example, transportation, commercial and communication services, and minor industrial uses.
8. Transportation;
    8.1. Transportation zoning districts have the purpose of maintaining transportation corridors such as road and rail and preventing areas from being converted into non-transportation uses.
9. Park & Open Space
    9.1. Park & Open Spaces have been found to promote mental health benefits and facilitate exercise.

6.3. Regression Model Testing Process

Performing the regression model testing and validity testing for statistical analysis is an essential part of ensuring that the results found from the methods enforced aren't random and that the data used is valid for the purposes it is being used for. A regression analysis relies on several assumptions that must be validated for the result of the analysis to be valid. Without these tests, unforeseen results based on data problems can be wrongly taken as false assumptions. With the purpose of ensuring this validity from the multiple linear regression the normal distribution, homoscedasticity, significance, linearity, independence and endogenities assumptions were verified.

Individually each dependent variable data was verified to be a normal distribution, this test is important to verify that enough variation was included in the test sample population. Homoscedasticity was tested for by running a regression against the predicted values from the multiple regression with the square of the residuals. Within the new regression output, the P value for F was verified to be significant or otherwise. If the null hypothesis was not rejected signifying that we can reject homoscedasticity, indicating that the alternative hypothesis is utilizing real non-artificial data and isn't biased. Homoscedasticity is a test performed to ensure that the data is not artificial and contains varied parts as it tests for variance of the dependent variables.

The following tests were only performed in the regression analyses combinations that passed the p-value significance test of 0.1 (Residential and adult physical inactivity rate / Park & Open Space zoning and psychological distress rate), further testing their dependent and independent variables. The dataset was checked to verify if the significance F value failed to reject the null hypothesis against an alpha value of 0.1. If so that indicates that there is a linear relationship between the dependent and independent variable making that alternative hypothesis significant. The correlation test significance and method are explained in sections 6.5 Data Analysis and 8.1 Correlation Analysis. The correlation test also served the purpose of testing for endogeneity. Residual graphs were created to check the independence assumption of the multi-variable regression model. Testing for independence is important to ensure that one variable data point does not fully depend on the outcome of another ensuring validity in the sample. Linearity was tested by creating graphs from the data to visualize that the relationship is not linear and truly natural. Finally, a multi-collinearity was tested by verifying that the variance inflation factor (VIF) of 1/(1-R^2) for each independent variable, where a VIF of over 4 indicates bad data for the analysis. Here most VIFs fell in between the 1 to 2 range which are good values for the purpose of the analysis. The multi-collinearity test is performed to ensure the precision of the data studied further ensuring that the independent variables data is statistically significant.

In conclusion, performing a complete regression model validity testing is essential to ensure the reliability and validity of the results obtained. Collectively the assessments of normal distribution, homoscedasticity, significance, linearity, independence and endogenity ensure the results aren`t biased and verifiable by other professionals. This way increasing the credibility of the results and data used.

6.4. Mapping Tool

Spatial mapping tools such as ArcGIS and QGIS are essential to facilitate spatial planning analyses involving zoning. It is not possible to fully understand zoning interactions with a neighborhood without being able to identify where they are located and which other zones surround it, adjacently or otherwise. The spatial analysis approach is indispensable for an accurate interpretation of the relationship between the physical environment in the case of this thesis because of two core factors. First, the data required to identify zoning boundaries while occasionally available in formats such as Excel is traditionally formatted to be understood through the use of GIS. GIS displays and contains information regarding the area occupied by a zoning district that can be worked with in a map format, whereas the Excel format in this case, commonly does not contain such information necessary to identify spatial features such as borders in a map and neighboring zoning districts. Secondly, an analysis of physical space is best done when you can identify spatial features exterior to the data being analyzed that may influence the results of the research. One such example is identifying how the format and shape of the terrain being investigated affect research. As such surrounding natural and man-made barriers dictate where zoning lines are drawn, and visualizing those in a map is the best method to identify those natural barriers. Those barriers can consist of many things such as highways, mountains, or bodies of water. These same barriers are also a good indicator of areas where pedestrians might not cross hence facilitating the prediction of what areas residents will likely occupy once they leave for any nearby activity. All of this can be accounted for to understand the scope of influence in a geographical sense, such as how far away factors in an area may influence its surroundings. Furthermore, after the initial analysis, because the comparison is made based on a visual map, outlying differences in the comparison can be done with geographical characteristics and identified, unlike a purely statistical comparison upon a review of results if desired.

The ArcGIS tool is also limited and was only able to prove itself useful to a certain extent, as during the development of the map for analysis some challenges occurred. The tool was limited as to how it was able to handle the data, being unable to summarize multiple different datasets combined, in this case, QGIS software was utilized to finish the analysis. Furthermore due to the large amount of data being processed ArcGis was often slow and crashed on occasion, slowing the analysis process. Along with this, time was spent

researching some of the analysis tool functions due to the non-intuitive software GIS interfaces requiring further study for proper use.

6.5. Data Analysis

A statistical correlation coefficient analysis was performed between each mediating variable of psychological distress, physical inactivity, overall health status, low food access, and poverty rates to identify any overarching patterns in the whole data set utilizing the correlation coefficient formula automated through the data analysis tool in Excel. In this case, the closer to -1 or 1 the more correlated both variables are where being close to 1 would be a positive relation and to -1 a negative.

While the statistical correlation analysis in combination with an initial quantification of variables through the use of Excel or GIS can give an insight into the presence of correlation, it does not facilitate a comparison of all variables simultaneously, being limited to comparisons within its variable groups. With the objective of facilitating the choice of which zoning designations are most likely to lead to a health-oriented outcome a comparison between those designations is important to not only understand the interactions between the individual variables and individual zoning but also to understand how each zoning classification influences the environment in comparison to all others in addition to its own individual influence.

The issues can be remedied by attempting to solve this issue in combination with a quantitative regression analysis. The regression analysis permits for a single dependent variable to be compared in relation to a singular or group of independent variables allowing for it to be quantified from the perspective of the group of independent variables as a whole. Furthermore, regression analysis is agreed to be able to show cause and effect, unlike a correlation analysis that indicates a relationship. However, due to having to handle multiple variables simultaneously, the results from regression analysis are capable of being impacted by outliers and so unable to thoroughly identify relations in multiple groups of variables simultaneously resulting in an incomplete view of the variables' relations.

To account for the presence of a zoning type summarizing the number of instances of each zoning within each individual community would not have provided a proper representation of the intensity of which each zoning is present in a neighborhood. To get an accurate picture the actual area that each zoning covers was measured using GIS instead. That is because the number of occurrences of zoning designation is not indicative of the major presence of a zoning type. Measuring the areas is a process that could only be performed through software such as GIS and is not possible in other non-geographical data analysis tools. In order to effectuate this method the geometry of the zoning data had to be fixed and sorted before the GIS software is able to read the map data.

Within each zoning variable group, too much missing data dis-classified a zoning area from being analyzed, while there was no missing data within the mediating health variables. The variables excluded are highlighted in the next section.

6.6. Data Handling

In ArcGIS, QGIS, and Excel the following steps were taken with the data in the following order (Names with the same color represent the same data file):

1. The data collected was downloaded from its respective websites in an Excel format with the Boundaries, Community Areas Map accurate to the years 2016-2023 downloaded in a .prj format from the Chicago Data Portal. The data was acquired with Longitude and Latitude coordinates, community area names, and GEOID identifiers within each dataset, where the GEOID was matched with the GEOID from the community areas and verified for accuracy by ensuring that the community area names were properly matched to themselves.

2. The Boundaries - Zoning Districts (current) (Shapefile) was renamed to zoning_2016 containing boundaries and a data file, and Boundaries - Community Areas (current) (Shapefile) were uploaded to ArcGIS and QGIS in shapefile format un-edited (City of Chicago, 2018).

3. With the aid of Professor Labib the geometry of zoning_2016 was fixed by debugging overlapping boundaries. The geometry was fixed by splitting the zones by community

area individually sorting each zoning category into smaller polygons that did not overlap with other areas. This way only the zoning area area that was within each community was counted for the one it was within.

4. Using the new zoning_2016 geometry the total area of each of the 12 individual zoning types was joined to the Boundaries - Community Areas sorted by the zoning that intersected with each community area resulting in a data set with the spatially joined areas. This generated the joined Community Areas dataset which contained a summary of how much of each zoning type was present within each community area, defined by the total area occupied in a percentage format.

5. Health variables data in .exe Excel format was downloaded from Chicago Health Atlas and had the explanation page removed before the variables were re-named from their acronym format for better readability before extracting the data.

6. The health data, sorted by community areas was then joined to the joined Community Areas map (Shapefile) utilizing community area numbers as the key. A matching of GEOID identifiers and a review of matching community names was performed to ensure proper join. This formed a combined data table and map holding the health variables assigned to each respective neighborhood in a shapefile format.

7. The analysis described in the methods was performed on the resulting data consisting of the two following statistical analysis methods:
    - 7.1. A correlation analysis for each individual variable contrasted with the zoning classifications utilizing the data analysis function in Excel.
        - 7.1.1. Tested and verified that excluding a zoning classification from the analysis did not change the output.
    - 7.2. Ran a regression analysis for each individual variable contrasted with the collective of zoning classifications with complete datasets utilizing the regression function in Excel.
        - 7.2.1. Checked the assumptions from the regression model, as described in the Regression Model Process section.

6.7. Limitations

6.7.1 External Limitations

This research method encountered the following limitations. It is unlikely to be able to account for all external factors influencing the health of individuals in their daily lives. Some of those factor that should be accounted for are wealth, professions, and personal activities. The large number of factors that influence health, can skewer the research results. In addition, a larger sample including multiple cities would have provided a more accurate result of the relation between zoning and health as a larger sample size tends to give more accurate results. Furthermore, due to the tests only having been performed in one city, there is the possibility of arriving at a different conclusion with the same method if they were to be re-done in a different location in view of the diverging ways cities operate.

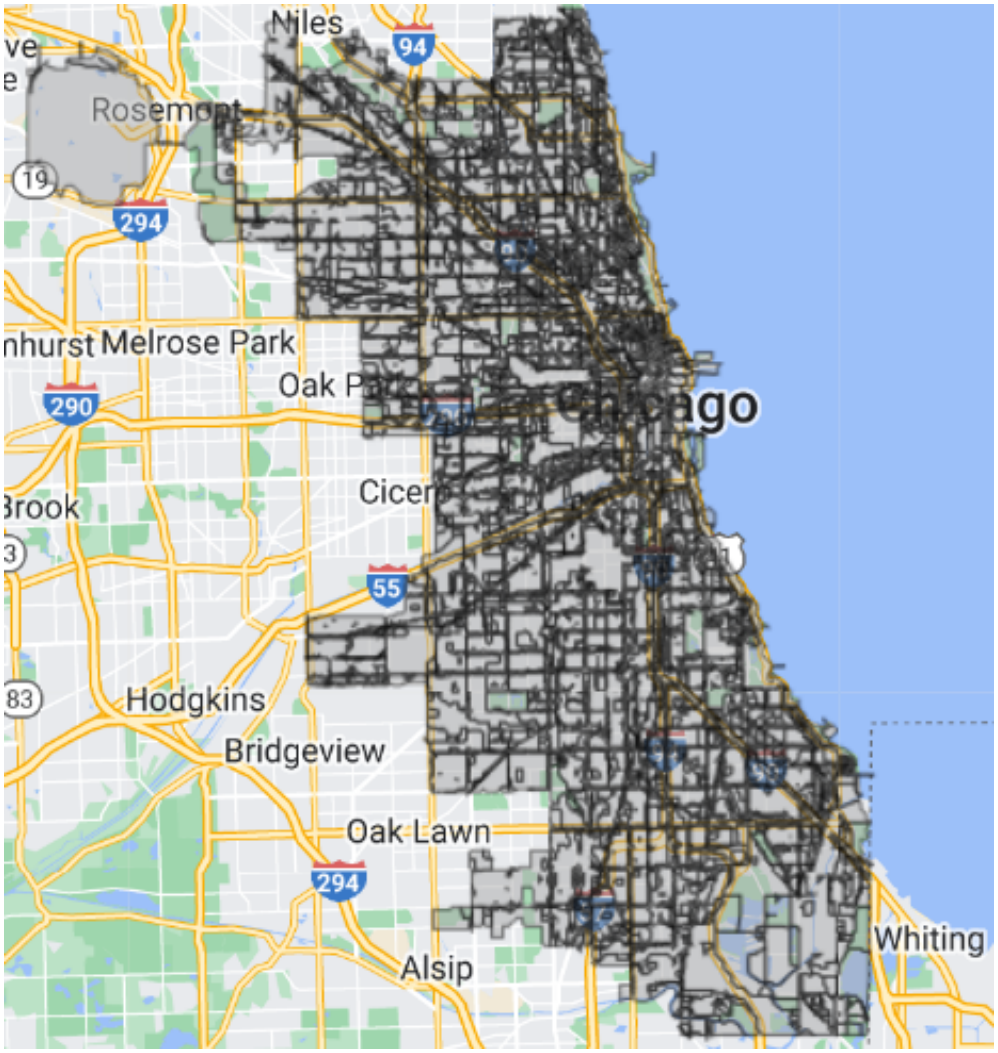
This thesis methodology approach was performed taking into account, that elderly and impoverished neighborhoods are likely to have a much lower health average and may skewer statistics when compared to other neighborhoods. During the analysis, the presence of economically disadvantaged communities was identified and accounted for. The split of those communities with prominent different demographics was considered but Chicago did not seem to have a visible impact on the average self-reported health for other than two communities significantly impacted. Also, the presence of elderly communities could not be easily measured and quantified with the data available which could have impacted the analysis, a demographic capable of skewing the psychological, general health, and physical activity variables in a community.

6.7.2 Data Limitations

The following zoning classifications were not considered for the final analysis in view of the following reasons. Planned Development, Planned Manufacturing, and Manufacturing were accounted for in the data handling phase but were not relevant for the purposes of the analysis. Downtown Mixed, Downtown Core, Downtown Residential, and Downtown Service zoning did not have enough data present in the majority of neighborhoods having only sufficient data present on average in 4 out of 77 neighborhoods tested and therefore not relevant for the analysis.

7. Chicago

This section introduces a summary of zoning bodies and processes in Chicago, a visualization of part of the process used in the analysis and introduces Chicago and its particular characteristics as they relate to the data analyzed.



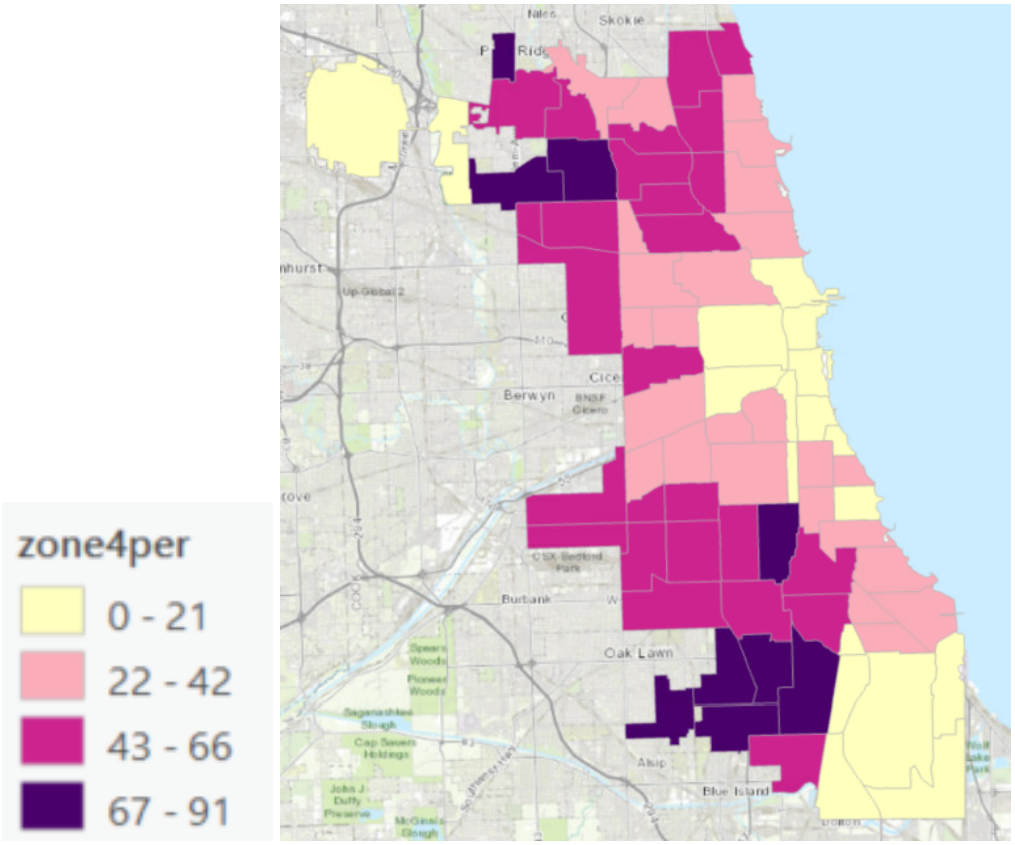
Map1 Boundaries - Zoning Districts (current) map retrieved from the Chicago Data Portal.

Map 1 displays all 12,223 zoning district boundaries in Chicago. The way zoning works in Chicago is that the city sets up zoning designations that control land use and development within the city. When zoning is re-classified it enters enforcement after the property within it changes its intended use until then the old classification is still valid. “The City has several administrative bodies for administering zoning issues, including the Zoning Board of Appeals, the Committee on Zoning, Landmarks and Building Standards, and the

Chicago Plan Commission. Notably, Chicago aldermen also play a significant role in nearly all zoning decisions that change the zoning designations or grant special uses in their individual wards." with large zoning changes needing to be approved by the City Council (Chicago Lawyers' Committee for Civil Rights, 2017). A good summary of how zoning is enforced in Chicago can be found in *Chicago Land Use: A Guide for Communities* (Chicago Lawyers' Committee for Civil Rights, 2017).

Located in the state of Illinois bordering Lake Michigan, Chicago is a city with roughly 591 square kilometers known for its trade, culture and art being one of the transportation hubs in America. It is also known to be a metropolis with a car-centric environment working as its main method of transport, while the city still hosts a fair amount of sidewalks and walkability. The city itself has few natural geographical barriers, the one evident barrier it hosts is its system of highways that cuts through the urban fabric in seven sections. Due to this a lot of its neighborhoods are divided in accordance with avoiding those highways. Furthermore, pedestrians have limited access to crossing them, relying on spaced bridges and stoplights.

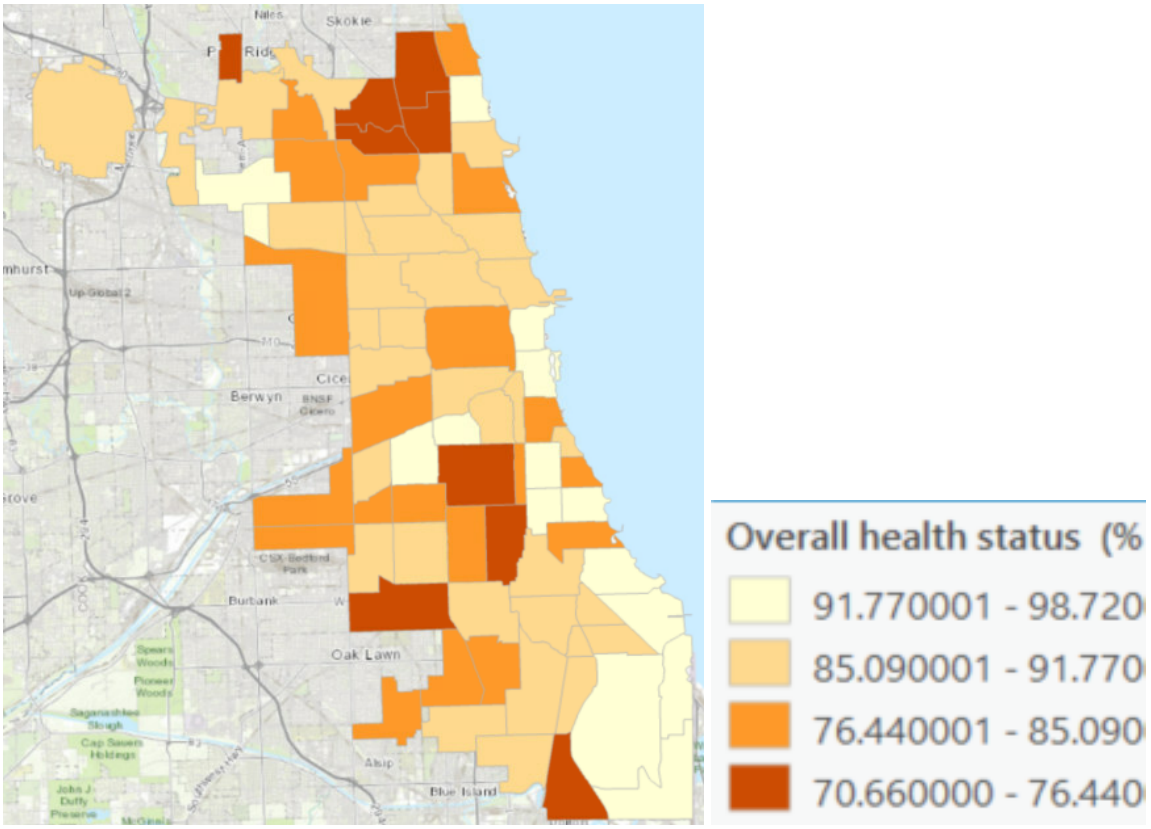
During the GIS section of this thesis, the following maps were created showing residential zoning density and overall health status. As visible on the maps on the following page Chicago is a city with residents of relatively good health with the majority of its population considering itself to be healthy and only 30% of the neighborhood citizens considering themselves unhealthy in the worst cases. Furthermore, the city contains a variation of residential configurations within its borders having neighborhoods with a residential density of 91% and all the way down to 0.01%. Controversy there is a gap of 15% between the better health neighborhoods and those with a lower average health health, meaning there is room for improvement.



Map 2 Residential Zoning Density

(Base map from ArcGIS & made with Chicago Health Atlas data)

Map 2, Residential Zoning Density shows the zoning area density within four different levels of density, each level relative to a representation of low, moderate, medium, and high amounts of residential zoning in a given neighborhood given the average in the city.



Map 3 Self-Reported Overall Health Status

(Base map from ArcGIS & made with Chicago Health Atlas data)

Map 3, Self-Reported Overall Health Status displays the average self-reported health divided into one of four brackets. With those brackets representing a natural division in the data.

8. Analysis

The analysis section provides an outline of the results from the tests performed based on the method described in the methodology section. The results were measured with the purpose of identifying any evident relationships or lack of between zoning designation types and measure of average health represented by the zoning classifications and health variables respectively. This analysis consisted of two analysis methods utilizing the same dataset, a correlation analysis identifying the individual relation between each dependent variable and independent variables and a regression analysis identifying the collective relationships between an individual dependent variable and the group of independent zoning variables. The correlation analysis was performed between each individual dependent and independent variable as pairs, Commercial with physical inactivity for example and all was calculated collectively through automatisation. The multiple regression analysis was performed between each dependent health variable and all complete datasets together, that being physical inactivity collectively calculated with Business, Commercial, Manufacturing, Residential, Planned Development, Planned Manufacturing, and Park & Open Space. Each of the regressions was calculated separately when automated.

8.1. Correlation Analysis

Data labels for Chicago zoning types subtitles

1. Business
2. Commercial
3. Manufacturing
4. Residential
5. Planned Development
6. Planned Manufacturing
7. Downtown Mixed
8. Downtown Core
9. Downtown Residential
10. Downtown Service
11. Transportation
12. Park & Open Space

Left black are the independent variables utilized during the whole of the study. Highted in red are the independent variables utilized during the analysis and not explored during the results. Highlighted in yellow are the independent variables discarded during the analysis due to insufficient data.

Correlation Analysis	Overall Health Status	Poverty	Low Food Access	Physical Inactivity	Psychological Distress
1. Business	0.042	-0.125	-0.020	0.063	-0.040
2. Commercial	0.083	-0.160	-0.098	0.037	-0.016
3. Manufacturing	0.050	-0.151	-0.036	-0.112	0.089
4. Residential	*** -0.3659**	*** 0.2411**	*** 0.2547**	*** 0.1896**	-0.130
5. Planned Development	0.076	0.077	-0.078	-0.011	0.123
6. Planned Manufacturing	*** 0.2741**	-0.042	-0.147	-0.130	0.044
7. Downtown Mixed	0.181	0.007	-0.181	-0.189	0.066
8. Downtown Core	0.138	-0.048	-0.162	-0.154	0.092
9. Downtown Residential	0.171	0.093	-0.124	-0.142	-0.033
10. Downtown Service	0.099	0.029	-0.145	-0.139	0.130
11. Transportation	-0.011	0.013	-0.036	*** -0.211**	*** 0.1978**
12. Park & Open Spaces	0.080	-0.132	-0.069	0.029	-0.082

Table 1; Correlation Analysis

For the Correlation Analysis table above the values who passed the hypothesis tests have a "*", for a test with the p value of 0,10. Those who failed the hypothesis test are left without the "*" symbol and do not have a significant correlation value according to the test. The table contains zoning designations on the first column and health variables on the first

row. The values within the boxes generated in the analysis represent the likelihood of correlation. Values closer to 1 or -1 indicate a strong correlation and those values closer to 0 do not correlate and therefore need to be discarded in accordance with the correlation analysis performed. The values highlighted in magenta are significant correlate values, whereas the zoning designations marked in yellow did not contain sufficient data for accurate analysis and therefore should be disconsidered due to inaccurate results. A positive correlation indicates that an increase in the area occupied in a neighborhood as a percentage of the total available space leads to an increase in the correspondent variable, and a negative correlation indicates that as the area occupied increases the health variable decreases.

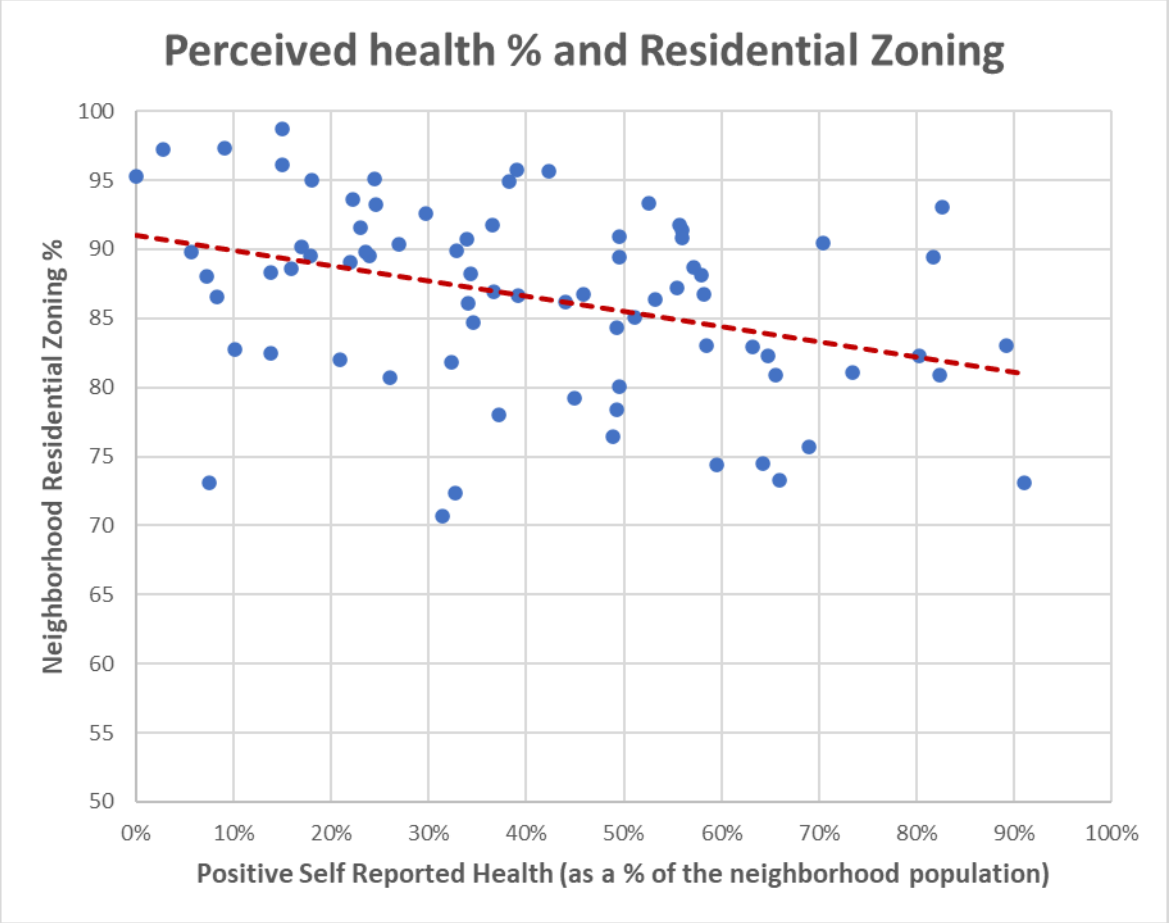
The analysis consisted of a sample size of 77 neighborhoods utilizing Pearson's critical values table;

Thus assuming a two-tail test with a significance level of 0.05, the resulting critical value for this sample would be ±0.224.

Conversely, for a more lenient scope of interpretation, utilizing a two-tail test and a significance level of 0.10, the resulting critical value for this sample would be ±0.189.

Therefore from the results presented in this correlation analysis table, it is possible to assume that a high concentration of residential zoning decreases positive self-reported health well-being, increases poverty, and is more likely to be a neighborhood with less food access and less physical activity. These relationships are explored further in the coming parts of this analysis section. Had Downtown Mixed, Downtown Core, Downtown Residential, or Downtown Service been found to have an existing correlation, these variables findings would have to have been discarded due to the large amounts of missing data. Results with missing data could not be considered because the results from an analysis utilizing them would be skewed and not representative of the actual population. Due to this, it is not possible to make a reliable interpretation of the results regarding these zoning designations.

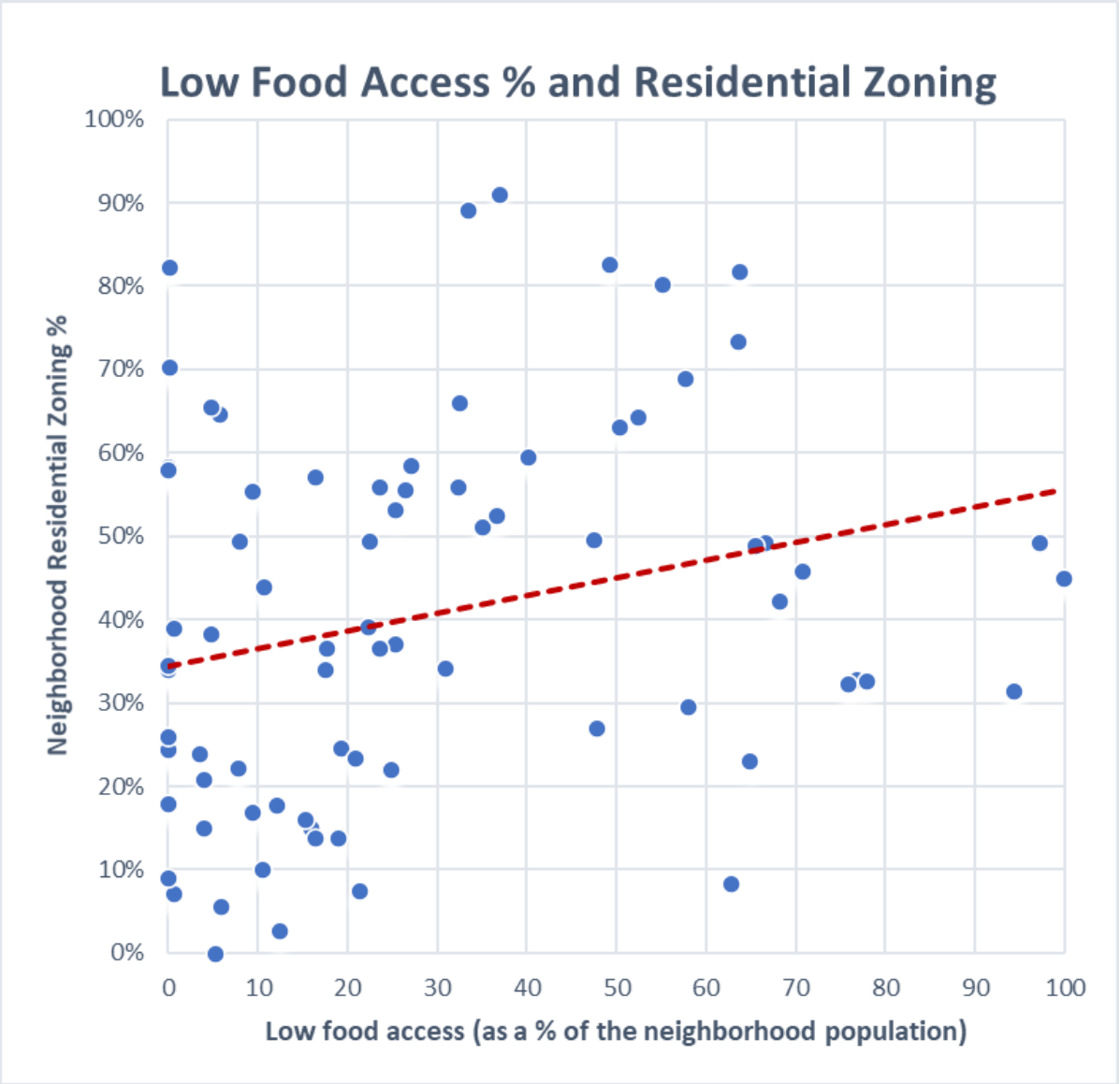
In the correlation table, there is a visible relationship in the trendline between a neighborhood having a higher residential zoning density and a detrimental effect on the self-reported population view of their health, access to food, and the rate of physical activity. Presenting a trendline in alignment with the indication of the correlation analysis. The four scatter plot graphs below contain dots each representing an individual neighborhood and a red trendline indicating the relationship between the variables. The Y axis of each dot represents the relative area occupied by residential zoning as a percentage of the total available area within that neighborhood and the X axis is the average variable value of the total qualified population within that neighborhood.



Graph 1; Perceived Health % and Residential Zoning

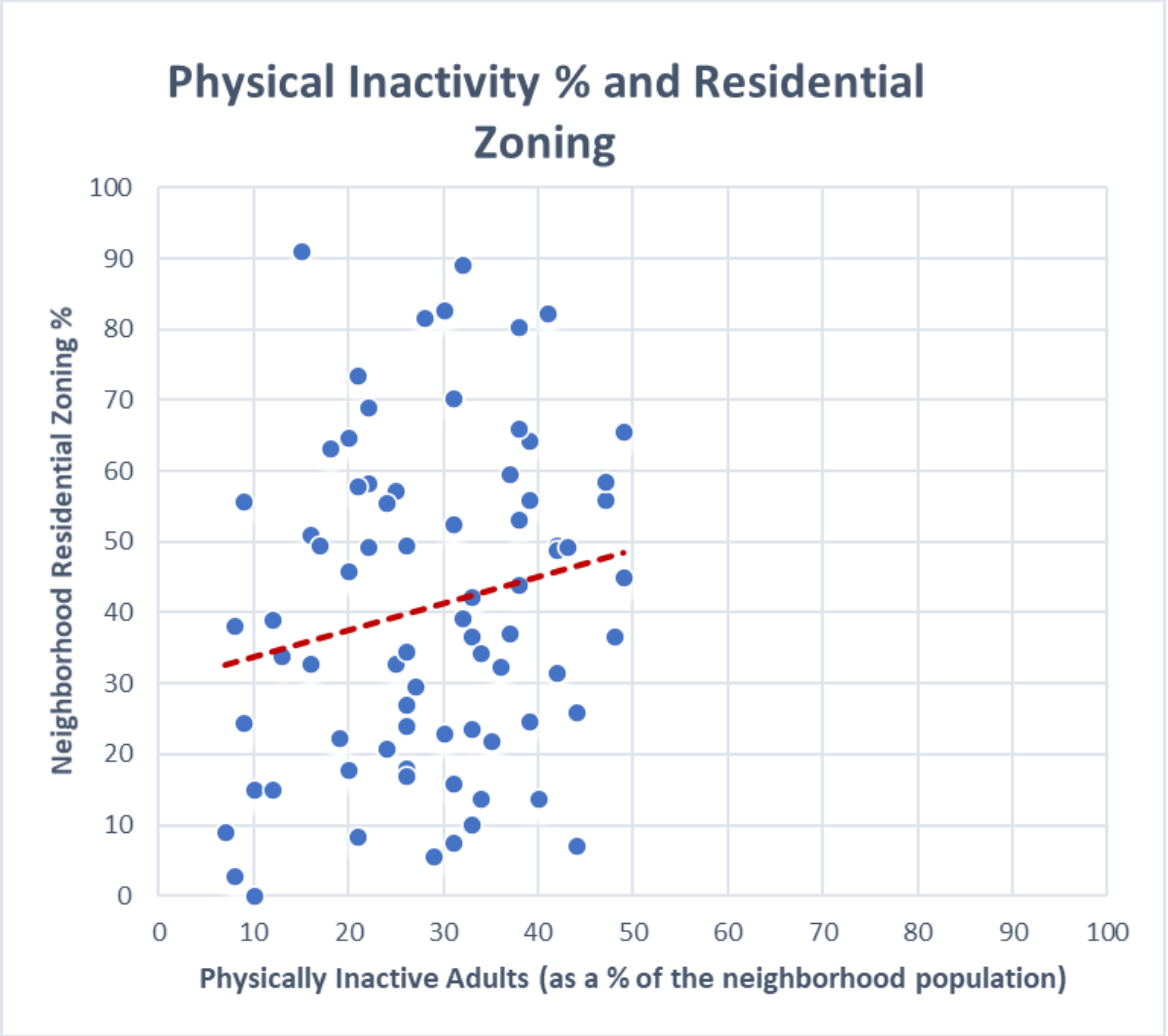
Graph 1, *Perceived Health % and Residential Zoning*, shows the relationship between the total land area occupied by residential zoning and the average self-reported health of neighborhood residents in Chicago. This relationship indicates that higher amounts of residential zoning coverage can lead to the average self perception of health being lower

compared to other neighborhoods in the same city with less residential.



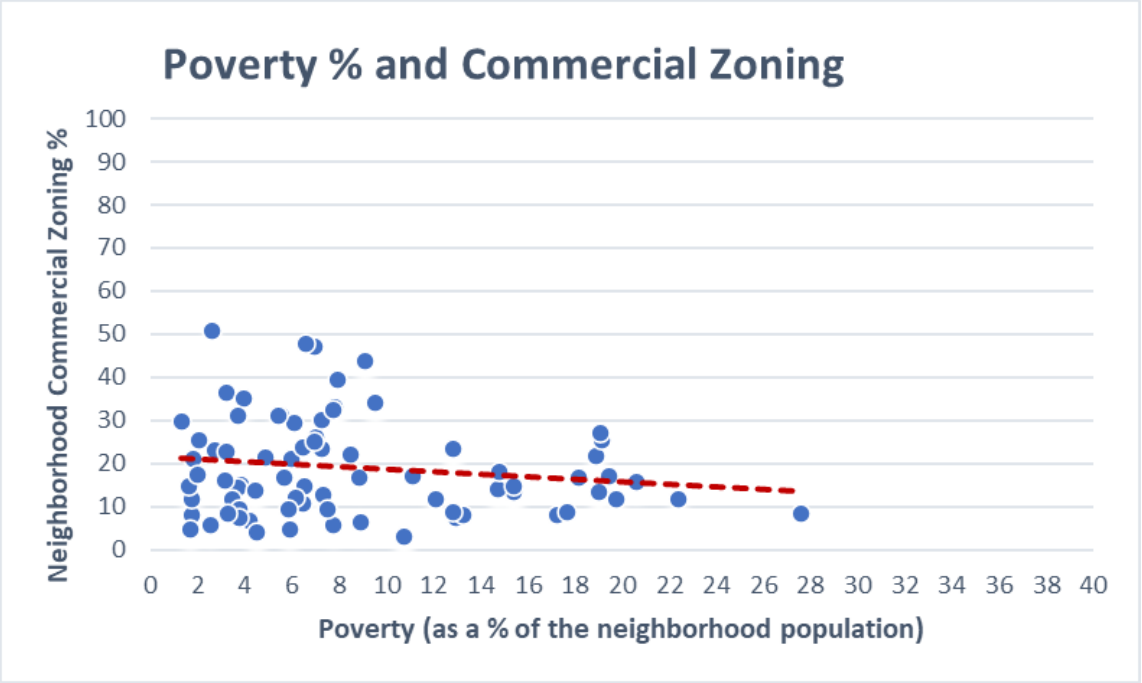
Graph 2; Low Food Access % and Residential Zoning

Graph 2; Low Food Access % and Residential Zoning shows the relationship between the total land area occupied by residential zoning and the number of residents who have low access to food as a total ratio of a whole neighborhood in Chicago. This relationship indicates that higher amounts of residential zoning coverage can lead to the average access to food decreasing compared to other neighborhoods in the same city with less residential.



Graph 3; Physical Inactivity % and Residential Zoning

Graph 3 shows the relationship between the total land area occupied by residential zoning and the average number of residents who reported to be physically inactive as a ratio of a whole neighborhood in Chicago. This relationship indicates that higher amounts of residential zoning coverage can lead to lesser levels of physical activity within that neighborhood compared to other neighborhoods in the same city with less residential.



Graph 4; Poverty % and Commercial Zoning

While it did not have a significant enough correlation score, commercial zoning districts, and poverty did come close to indicating a correlation. It is likely that poverty is prevalent in neighborhoods with less commercial zoning as impoverished areas tend to have less interest in investing in businesses. Furthermore, commercial action tends to lead to more economically developed neighborhoods as more jobs are available. The correlation relationship between poverty and residential is further disproved during the regression analysis.

8.2. Regression Analysis

By utilizing the Excel regression tool the relationship of a single dependent variable was compared to the group of independent variables. Through this comparison, another verification of the relationship between variables was possible by viewing the P-value results from the regression model. The P-value in statistical hypothesis can be used to verify if the relationship between a dependent variable and an independent variable is (un)likely to be random. During this step, it was verified that the relationship between physical inactivity and residential zoning coverage is only 8% likely to be random. Controversely the relationship of perceived health of 40%, low food access of 19.7%, and poverty at 92% P-value indicates that it is insufficient proof of a relationship between them and and the volume of residential zoning. Henceforth the relationship found in the correlation analysis has to be interpreted with caution for perceived health and low food access and discarded for poverty because they are likely to be random and should therefore be discarded. Due to these results, it is possible to assert the relationship between residential zoning occupation rate and physical health impacts.

The multiple linear regression indicated that there were two cases where there was a significant correlation. Between Residential and adult physical inactivity and between Park & Open Spaces and psychological distress. After testing for the significance F between Park & Open Space and improving mental health failed to reject the null hypothesis and therefore does not have linearity, signifying that the results from that test did not pass the reliability tests required of this statistical analysis. The relationship between Park & Open Space and improving mental health is already a well-known relationship in the planning community but cannot be considered as a valid assumption based on the results of this test. Failing this test does not mean that there is no relation between psychological distress and Park & Open Space, only that the data from tests it was performed from is not able to generate a reliable result indicative of the presence or lack of correlation.

Meanwhile, the connection between an increase in residential and decreasing physical activity passed all tests listed under the *Regression Model Testing* section of this thesis. The relation between residential areas and physical health is a less-explored hypothesis in the literature that was indicated to be significant.

The tables below contain the results of a regression analysis utilizing the Excel regression tool. The tables display the Independent variables, coefficients, standard Error, and P-value of the respective regression analysis dependent variable displayed on the table title. P-values that were found to have a likely chance of not being random from the regression analysis were marked with a "*" based on the cut-off point of $p < 0.1$ (10%). A positive coefficient indicates that as the dependent variable increases the independent variable will also increase, while a negative coefficient indicates that the dependent variable decreases as the independent variable increases.

Table 2, Overall Health Status Multiple Regression Analysis

Independent Variables	Coefficients	Standard Error	P-value
Intercept	97.45	23.87	0%
Business	34.88	51.33	50%
Commercial	-44.94	56.68	43%
Residential	-19.45	22.92	40%
Park & Open Spaces	-14.39	51.83	78%
Manufacturing	-8.34	23.79	73%
Planned Development	-10.65	29.96	72%
Planned Manufacturing	-1.92	24.30	94%
R Square	0.17	Observations	77

Table 3, Physical Inactivity Status Multiple Regression Analysis

Independent Variables	Coefficients	Standard Error	P-value
Intercept	-40.65	42.20	33.9%
Business	62.76	90.76	49.2%
Commercial	113.73	100.21	26.0%
Residential	71.93	40.53	**8.0%***
Park & Open Spaces	29.82	91.65	74.6%
Manufacturing	60.71	42.07	15.4%
Planned Development	80.88	52.97	13.1%
Planned Manufacturing	61.96	42.97	15.4%
R Square	0.08	Observations	77

Table 4, Psychological Distress Multiple Regression Analysis

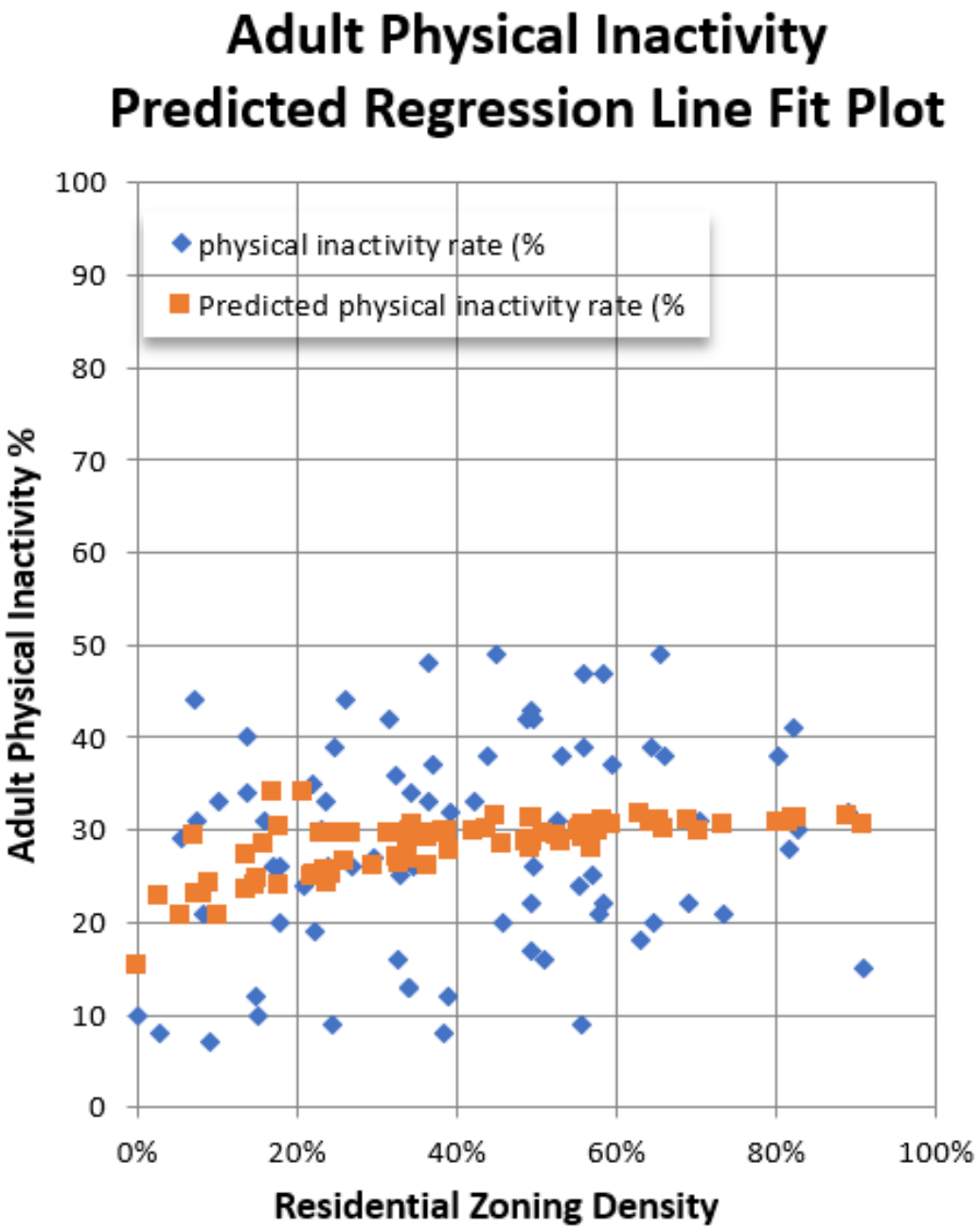
Independent Variables	Coefficients	Standard Error	P-value
Intercept	39.09	39.94	33.1%
Business	74.91	85.91	38.6%
Commercial	113.13	94.86	23.7%
Residential	-6.60	38.37	86.4%
Park & Open Spaces	-193.50	86.76	**2.9%***
Manufacturing	4.83	39.82	90.4%
Planned Development	15.26	50.14	76.2%
Planned Manufacturing	1.22	40.67	97.6%
R Square	0.11	Observations	77

Table 5, Low Food Access Multiple Regression Analysis

Independent Variables	Coefficients	Standard Error	P-value
Intercept	-85.31	99.95	39.6%
Business	217.40	214.98	31.5%
Commercial	-96.22	237.38	68.6%
Residential	125.03	96.01	19.7%
Park & Open Spaces	183.96	217.09	40.0%
Manufacturing	111.92	99.65	26.5%
Planned Development	131.29	125.47	29.9%
Planned Manufacturing	99.64	101.78	33.1%
R Square	0.09	Observations	77

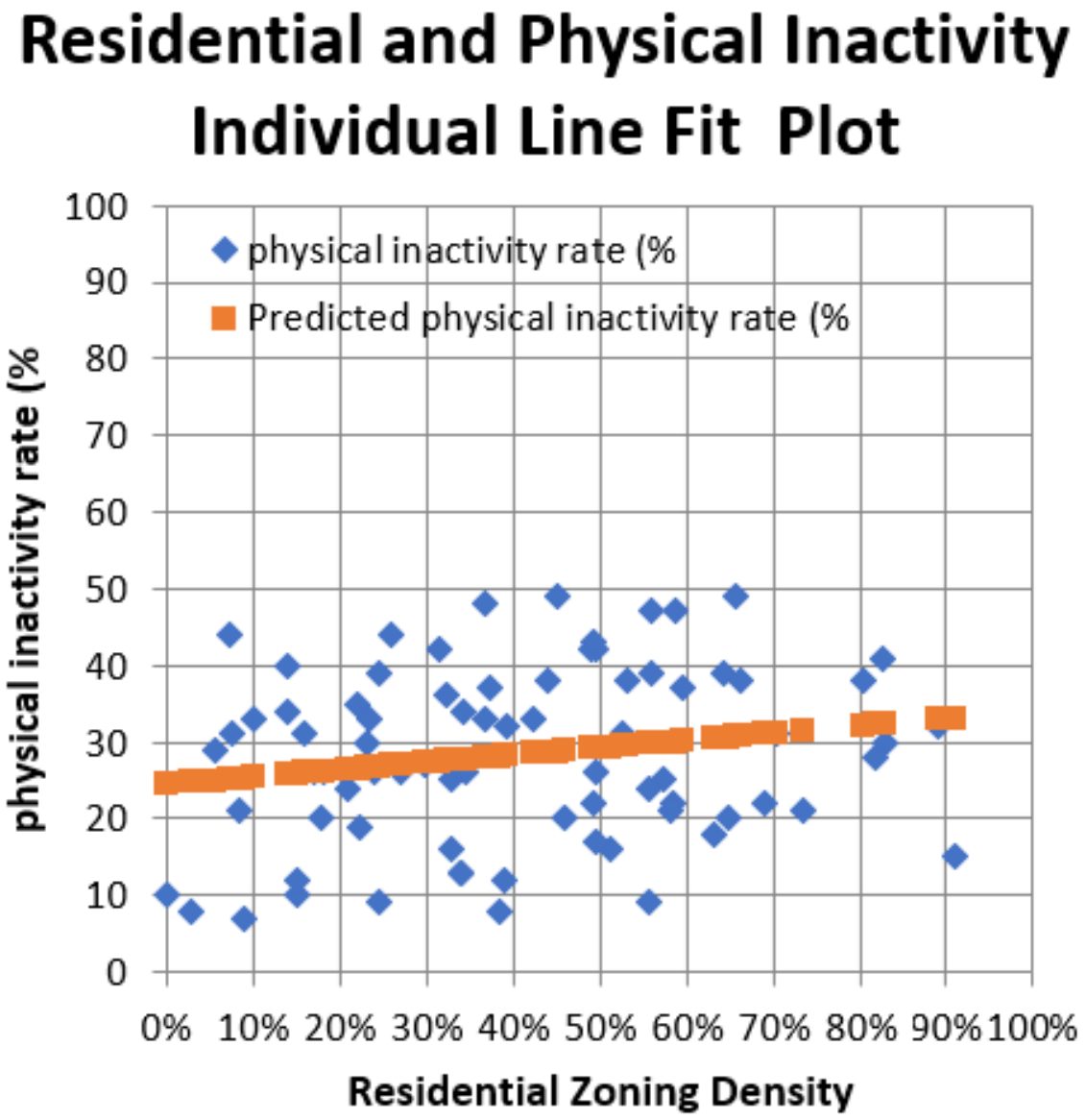
Table 6, Poverty Multiple Regression Analysis

Independent Variables	Coefficients	Standard Error	P-value
Intercept	28.86	40.73	48.1%
Business	-78.83	87.61	37.1%
Commercial	-44.63	96.73	64.6%
Residential	3.90	39.13	92.1%
Park & Open Spaces	65.85	88.47	45.9%
Manufacturing	-18.49	40.61	65.0%
Planned Development	7.75	51.13	88.0%
Planned Manufacturing	-9.67	41.48	81.6%
R Square	0.12	Observations	77



Graph 5 Residential and Adult Physical Inactivity, Regression Line Fit Plot

Graph 5, Residential and Adult Physical Inactivity scatter plot contains a prediction of the average physical inactivity rate in a neighborhood as a result of the shift in residential zoning coverage. This prediction is based on the statistical pattern identified by the multiple regression analysis tool in Excel. The relation presents a graph with evident linearity and also contains an R squared of 0.08 indicating that 8% of changes in physical activity can be attributed to a change in the amount of residential zoning density with a 92% certainty due to the 8% P-value. 92% of changes in physical health are therefore caused by other factors such as the presence of disabilities or too many rainy days in the year.



Graph 6 Residential and Adult Physical Inactivity, Individual Line Fit Plot

Graph 6, Residential and Adult Physical Inactivity scatter plot contains a prediction of the average physical inactivity rate in a neighborhood as a result of the shift in residential zoning coverage as the result of a regression analysis that only accounted for the residential zoning and physical inactivity variables, excluding all other variables from it's analysis. Here it is visible that there is a much more linear relation between residential zoning distribution and physical inactivity if compared without any external influences.

8.3. Findings

The regression analysis indicated that for each 1% increase in residential zoning area coverage, the physical inactivity rate is likely to increase by 71.93% from the 8% that residential zoning influences physical activity indicating a total increase of 5.75% in physical inactivity from the last recorded value for each 1% increase in residential zoning area coverage. This influence ranged from 2.51% up to 9% accounting for the standard error of 40.53. Also assisting with a visual representation the line fit plots of graphs 5 and 6 provided an estimation of what the predicted rate of physical inactivity would be compared to the area occupied by residential zoning in a city like Chicago. These graphs indicate an average variation in physical inactivity between 16% - 34% as the results of a residential zoning area coverage ranging between 0.01% - 91.04% where the likely relation became more linear after +-40% residential zoning coverage.

These analyses revealed a statistically significant regression and correlation utilizing a P-value of 0.1 between the residential zoning and physical health outcomes. During the Correlation Analysis section it was identified a correlation between increased amounts of residential zoning presence in a neighborhood and the overall health status, poverty, low food access, and physical inactivity of citizens living within that neighborhood. This indicated a relationship between an increase in residential zoning and the detriment of health. In the following section, the regression analysis tests indicated that the relationship between increased amounts of residential zoning presence in a neighborhood and the overall health status, poverty and low food access of citizens living within that neighborhood did not have a statistically provable relationship lacking proof of causation. The same tests also confirmed the hypothesis that there is a relationship between an increase in residential zoning and an increase in physical inactivity within a neighborhood level.

During the analysis, it became evident that the concentration of residential zoning contributed to up to 8% of the factors motivating physical activity. and that higher areas of residential zoning lead to poorer health. This negative effect is likely caused due to the scarcity of diversity that a higher concentration of residential promotes. By dedicating more space to residential, less space is left for other zoning types containing essential amenities, such as Commercial, Business and Park & Open Space. This imbalance is also likely to further discourage physical activity due to the lack of locations to exercise in and the

limitation of desirable destinations that are walkable. This pattern of infrastructural distribution is often seen in suburban neighborhoods. The issue identified in suburbs is characterized by their vast low-density housing occupation split from commercial, business, and essential development. Suburbs have been found to be detrimental to health through car-centric air pollution, heat, “lack of defined activity centers” (Miller, 2018), and by limiting inter-social interactions (Chen et al., 2023).

The majority of zoning designations did not present a clear correlation between their impact on health and their presence either likely due to truly not having a significant impact on the measured variables or due to the large amount of exterior influencing factors that affect the health of city residents diminishing the accuracy of the data. It is unlikely for this research method to be able to measure the whole scope of health influential aspects in view that the urban shape has a limited direct impact on most sociodemographic data. Since Labib, Lindley, and Huck’s research found that sociodemographic data is the most agreed upon to measure the influence of health. The hardships of quantifying and splitting these externalities from the resulting average health limit the measurable results. Hence another reason why this research has arrived at the found relations could be attributed to unpredicted differences in the data as a result of combined external factors.

8.3.Discussion

While proving regression and correlation does not directly prove causation, it can be inferred based on a strong theory linking the variables being tested. The method identified through which too much residential leads to poorer levels of physical activity is that when an area predominantly has residential the likelihood of amenities being able to be present within walking distance decreases leading to poorer physical health. The concept that an area saturated with residential zoning leads to overall worse health is aligned with Chen’s residential density research (Chen et al., 2023). In an urbanized city context where every space within the city is being utilized medium-density blocks typically emerge in locations characterized by a higher concentration of residential zoning due to their low construction costs. Within a metropolis like Chicago, an equal demand for housing can be satisfied by promoting high-rises leaving more space for other types of infrastructure and leading to healthier neighborhoods. The opposite is also true where a larger area dedicated to housing will leave less space for different kinds of beneficial infrastructure, especially within

neighborhoods with no space to grow outwards such as in Chicago.

Park & Open Space zoning having not passed the correlation significance test with mental health was an unexpected finding. This finding contradicted what the literature section and what recent research has found to be an existing relation. The lack of correlation found during this test could have been attributed to a large number of different aspects impacting mental health that are not dependent on urban configuration compared to the other health variables measured. Similarly, Commercial and Bussiness zoning having not passed the regression and correlation tests was expected as the researched literature pointed towards these types of zoning imposing a randomly positive or negative influence on health, therefore not being inclined to only improve or only detriment health impacting the statistical testing.

When attempting to highlight the relationship between residential zoning density and levels of physical activity in a neighborhood we may refer back to Ransom's concept that areas with mixed-use development create incentives for physical activity by having amenities within walking distance supported by many other studies (Ransom et al., 2011). An area with distinct and mixed zoning categories within one zoning area is also known as mixed-use development and has been known to promote healthy behaviors by incentivizing walking, biking general physical activity, and offering easy access to essential goods and services (Ransom et al., 2011). The concept that mixed-use is beneficial to physical activity levels and overall health is also present in the 15-minute city concept. Within planning the concept of a 15-minute city has become a popular topic and example of what may consist of a healthy city. Those are cities with neighborhoods that host all essential amenities within a short bike ride or walk from every individual's home. Having all necessities within a short amount of distance saves commute time that individuals can use for self-care (Moreno et al., 2021). The 15-minute city and the mixed-used zoning follow an identical logic where a mix of zoning designations will promote the presence of as many desirable amenities within a short distance. If Chicago were to adopt a similar practice philosophy to 15-minute cities it could easily use its neighborhood boundaries as measures, that is, according to Google Maps, the time to cross most neighborhoods in Chicago by bike is about 15 minutes. Thus applying zoning practices utilizing the 15-minute city philosophy neighborhoods would promote citizens' healthy behaviors.

Chicago's distinct characteristics may have influenced the results of this study. Being a metropolitan city, it tends to have a majority of buildings with medium to high rises which indicates the presence of a highly dense population. A residential district within the zoning regulations of Chicago does not permit commercial activity such as shops or restaurants and similar essential services such as grocery stores which are frequently used by residents. Consequently, a small residential area accounts for a large number of residents, and if their immediate vicinity lacks the necessary services all of them must seek them through methods other than walking. This situation contrasts with smaller cities where the same amount of residential zoning would house fewer residents leading to fewer individuals needing to travel. Essentially the lack of non-residential zoning within walking distance has a statistically disparate impact being present in Chicago over a smaller city as this absence is felt harder in a highly dense area.

9. Conclusion

In an attempt to answer the question of how zoning designations influence health within neighborhoods in Chicago, this research found an indication of a relation between how much area a zoning type occupies in relation to the available space. More specifically a relation between how much area is occupied by residential in opposition to the presence of other classifications. Even though the other analyzed zoning designations did not show a correlation during the analysis, existing research has previously proven the benefits of the built spaces those other zoning designations promote such as the relation between green spaces and benefits to mental health and research highlighting the health benefits of shopping strips (Lee & Maheswaran, 2011)(Rosenbaum et al., 2016). Throughout this paper, it also has become evident that the configuration of zoning designations directly influences the presence of infrastructure and spatial configurations that promote healthy habits considering the analyzed literature. In view of this overpopulating an area with residential zoning starves it of other beneficial zoning designations that promote healthy habits. Commercial and Parks & Open space zoning for instance promotes physical activity through the presence of nearby amenities and spaces to go outside. Yet the influence that zoning has over land use is limited by the market and requirements that take time to resolve. Thus zoning is more effective at preventing unintended uses in contrast with enforcing desirable ones. Because neighborhoods with a high variation of zoning denomination promote a mixed-use urban form within their neighborhood, the ideal manner to develop healthy growing neighborhoods in the future will be to create new neighborhoods with a diverse zoning balance between housing and zoning districts that promote other infrastructures to accommodate a growing population.

Suggestions for further studies include studies utilizing the information found in this thesis that might be useful to support arguments in favor of mixed-use and promoting walkable urban designs. My advice for planning practitioners seeking to use the findings of this thesis is to take in all factors included in planning decisions. It is important to keep in mind, for example, that homelessness is a significant issue in the United States, and there is a pull to move to large urban centers that attract immigration from other cities and raise the value of residential areas amongst other particulars. This dichotomy of differently weighted issues poses a limitation on the choices planners make and once again it is up to what is considered a priority for the decision maker. Still, the core issue that arises, concerns the tendency to follow a corrupted system influencing methods of decision-making prioritizing

select stakeholders and demographics over the benefit of the masses as brought up by Thornton and Maantay (Thornton et al., 2013) (Maantay, 2002). For anyone seeking to further expand on the findings of this thesis, I recommend using a wide array of cities of different sizes from different countries at different points in their development to generate a more global picture of the impacts of zoning resulting in an applicable use of the findings in a wide scale. Alternatively, a longitudinal study by inputting Chicago data from the coming years may also provide a clearer picture of the relationship between zoning and health as following changes throughout the years can provide evidence of how a zoning change has historically affected a neighborhood. The research as of now only reflects Chicago which is a metropolitan center following American urbanization tendencies from the last couple of years.

Even though zoning designations only make up to 8% of the total factors influencing physical activity, improving a population's health is a wicked problem that needs to be tackled through many different approaches in combination. Striving to make a neighborhood 8% better should be considered a significant improvement given the whole. Making planning decisions is a job that takes into account many different factors ranging from socio-economical demands to political alignments and now zoning configurations are a new factor that can be weighted and considered. Throughout this paper, it has been highlighted the impact that planning departments have on health through the enforcement of zoning. Hence according to the findings of this paper, if a decision maker's goal is to shape a neighborhood in a way to promotes a healthy environment, they should consider promoting a diversity of zoning types preventing an oversaturation of residential zoning areas. Yet this would be as challenging of practice as implementing 15-minute cities in the hopes of promoting a utopian future.

10. Appendix Data Values

10.1. Health Atlas Variables

The table below contains the data values from the Chicago Health Atlas utilized in this paper.

Area Nº	Neighborhood	Overall Health Status %	Poverty %	Low Food Access %	Physical Inactivity %	Psychological Distress %
1	ROGERS PARK	82.91	6.58	50.25	18.00	46.97
2	WEST RIDGE	74.46	43.98	52.34	39.00	47.90
3	UPTOWN	88.22	15.99	30.89	34.00	58.71
4	LINCOLN SQUARE	73.30	25.40	32.41	38.00	53.18
5	NORTH CENTER	90.82	12.15	32.35	39.00	38.19
6	LAKE VIEW	81.78	12.01	75.77	36.00	50.44
7	LINCOLN PARK	91.53	16.88	64.86	30.00	51.74
8	NEAR NORTH SIDE	89.85	27.26	5.77	29.00	39.83
9	EDISON PARK	73.10	29.97	36.92	15.00	34.86
10	NORWOOD PARK	87.20	8.87	9.39	24.00	26.83
11	JEFFERSON PARK	85.09	14.14	35.08	16.00	42.22
12	FOREST GLEN	86.93	21.84	17.59	33.00	27.40
13	NORTH PARK	70.66	17.13	94.25	42.00	40.54
14	ALBANY PARK	74.41	11.96	40.12	37.00	58.77
15	PORTAGE PARK	82.29	22.86	55.06	38.00	50.74

16	IRVING PARK	83.05	22.39	27.08	47.00	46.46
17	DUNNING	93.01	5.73	49.15	30.00	36.94
18	MONTCLARE	93.35	31.27	36.58	31.00	42.67
19	BELMONT CRAGIN	89.43	7.66	47.36	26.00	36.12
20	HERMOSA	91.73	16.35	23.53	48.00	59.06
21	AVONDALE	86.72	14.98	0.00	22.00	46.01
22	LOGAN SQUARE	91.77	4.98	26.39	9.00	62.54
23	HUMBOLDT PARK	86.61	39.65	22.25	32.00	42.88
24	WEST TOWN	90.70	3.33	17.52	13.00	60.23
25	AUSTIN	78.35	47.84	97.10	43.00	47.00
26	WEST GARFIELD PARK	89.82	16.95	20.87	33.00	24.36
27	EAST GARFIELD PARK	90.40	7.69	47.74	26.00	45.34
28	NEAR WEST SIDE	82.76	26.20	10.54	33.00	55.64
29	NORTH LAWNDALE	86.21	34.18	10.56	38.00	32.97
30	SOUTH LAWNDALE	80.73	13.88	0.00	44.00	55.45
31	LOWER WEST SIDE	88.30	23.44	16.43	40.00	47.03
32	LOOP	95.30	8.23	5.19	10.00	49.24
33	NEAR SOUTH	97.25	23.43	12.36	8.00	42.85

	SIDE					
34	ARMOUR SQUARE	88.64	9.62	15.22	31.00	42.29
35	DOUGLAS	82.04	13.66	3.90	24.00	43.20
36	OAKLAND	88.08	8.46	0.58	44.00	28.38
37	FULLER PARK	82.44	25.72	18.84	34.00	53.50
38	GRAND BOULEVARD	95.66	13.42	68.21	33.00	46.41
39	KENWOOD	77.98	25.43	25.24	37.00	23.65
40	WASHINGTON PARK	93.23	18.37	19.17	39.00	50.57
41	HYDE PARK	94.99	11.92	0.01	26.00	42.68
42	WOODLAWN	84.67	14.93	0.01	26.00	43.91
43	SOUTH SHORE	94.95	8.31	4.68	8.00	43.95
44	CHATHAM	90.88	8.52	7.90	17.00	57.95
45	AVALON PARK	86.10	11.00	0.01	13.00	20.69
46	SOUTH CHICAGO	95.05	9.45	0.00	9.00	37.15
47	BURNSIDE	89.51	14.40	12.10	20.00	44.26
48	CALUMET HEIGHTS	89.56	11.78	3.39	26.00	8.49
49	ROSELAND	90.44	11.86	0.08	31.00	22.64
50	PULLMAN	86.57	4.96	62.78	21.00	45.96
51	SOUTH DEERING	97.32	9.62	0.00	7.00	52.91

52	EAST SIDE	98.72	5.98	3.93	10.00	49.12
53	WEST PULLMAN	88.70	17.68	16.39	25.00	41.41
54	RIVERDALE	73.08	29.71	21.37	31.00	46.11
55	HEGEWISCH	96.09	4.34	15.90	12.00	27.88
56	GARFIELD RIDGE	80.10	36.66	22.34	42.00	33.07
57	ARCHER HEIGHTS	89.90	15.11	76.78	25.00	45.48
58	BRIGHTON PARK	92.60	6.86	57.98	27.00	64.59
59	MCKINLEY PARK	93.62	35.39	7.80	19.00	61.50
60	BRIDGEPORT	89.10	8.24	24.83	35.00	49.45
61	NEW CITY	72.39	16.74	77.88	16.00	42.68
62	WEST ELSDON	79.20	50.94	99.85	49.00	48.66
63	GAGE PARK	82.30	21.46	5.68	20.00	52.12
64	CLEARING	84.31	21.25	66.60	22.00	37.89
65	WEST LAWN	86.35	30.09	25.35	38.00	47.79
66	CHICAGO LAWN	86.72	33.19	70.77	20.00	45.53
67	WEST ENGLEWOOD	80.88	23.86	4.79	49.00	41.95
68	ENGLEWOOD	75.69	31.36	57.60	22.00	55.82
69	GREATER GRAND CROSSING	88.09	21.32	0.02	21.00	36.49
70	ASHBURN	76.44	47.35	65.46	42.00	36.85

71	AUBURN GRESHAM	91.34	12.72	23.49	47.00	46.18
72	BEVERLY	81.12	32.62	63.50	21.00	30.66
73	WASHINGTON HEIGHTS	80.87	31.12	0.05	41.00	20.38
74	MOUNT GREENWOOD	83.03	14.87	33.48	32.00	41.12
75	MORGAN PARK	89.44	23.09	63.67	28.00	38.73
76	OHARE	90.18	17.06	9.33	26.00	49.84
77	EDGEWATER	95.77	8.99	0.61	12.00	50.74

Table 7; Health Atlas Variables

10.2. Neighborhood Area Zoning Distribution

The table below contains the data values from the measurement of the % area occupied by zoning district categories within each neighborhood.

1. Business
2. Commercial
3. Manufacturing
4. Residential
5. Planned Development
6. Planned Manufacturing
7. Downtown Mixed
8. Downtown Core
9. Downtown Residential
10. Downtown Service
11. Transportation
12. Park & Open Space

Area Nº	**Neighborhood**	**zone 1 %**	**zone 2 %**	**zone 3 %**	**zone 4 %**	**zone 5 %**	**zone 6 %**
1	ROGERS PARK	13.87	8.90	3.73	63.17	5.31	0.00
2	WEST RIDGE	13.67	9.08	1.33	64.28	4.13	0.00
3	UPTOWN	23.58	20.56	0.83	34.28	1.90	0.00
4	LINCOLN SQUARE	15.31	6.94	2.58	66.01	2.73	0.00
5	NORTH CENTER	11.56	6.16	15.11	55.92	8.22	0.00
6	LAKE VIEW	25.28	19.74	1.55	32.33	2.69	0.00
7	LINCOLN PARK	21.93	18.12	4.08	23.04	9.03	7.34
8	NEAR NORTH SIDE	18.26	19.04	1.04	5.62	17.04	7.58
9	EDISON PARK	3.84	1.29	2.06	91.04	0.10	0.00

10	NORWOOD PARK	16.14	12.80	1.33	55.44	1.75	0.00
11	JEFFERSON PARK	17.61	14.70	2.20	51.08	0.33	0.00
12	FOREST GLEN	20.49	18.87	4.55	36.61	0.94	0.00
13	NORTH PARK	21.50	19.41	2.72	31.44	5.95	0.00
14	ALBANY PARK	15.44	12.08	0.86	59.51	1.72	0.00
15	PORTAGE PARK	9.86	3.19	3.47	80.29	1.30	0.00
16	IRVING PARK	11.76	8.45	12.30	58.50	3.78	1.70
17	DUNNING	8.46	2.55	0.20	82.65	4.56	0.00
18	MONTCLARE	11.21	5.39	4.75	52.56	4.47	18.93
19	BELMONT CRAGIN	11.05	3.75	4.85	49.58	5.44	23.30
20	HERMOSA	4.24	3.15	13.56	36.59	0.00	41.27
21	AVONDALE	10.09	6.51	14.75	58.27	5.38	2.40
22	LOGAN SQUARE	9.72	5.92	13.20	55.66	4.71	9.29
23	HUMBOLDT PARK	10.36	7.93	8.08	39.15	2.24	26.32
24	WEST TOWN	13.18	10.74	5.91	33.97	5.23	24.05
25	AUSTIN	9.29	6.58	12.83	49.27	2.65	15.51
26	WEST GARFIELD PARK	11.14	8.83	22.06	23.50	0.00	27.13
27	EAST GARFIELD PARK	9.68	12.91	10.19	26.95	6.30	26.84
28	NEAR WEST SIDE	9.41	7.00	4.10	10.14	25.35	27.21
29	NORTH LAWNDALE	8.70	9.52	16.60	43.99	6.50	9.71
30	SOUTH LAWNDALE	5.56	4.39	50.54	26.01	8.19	3.68

31	LOWER WEST SIDE	5.57	7.24	25.55	13.86	8.49	37.76
32	LOOP	16.60	13.22	0.00	0.01	32.67	0.00
33	NEAR SOUTH SIDE	15.50	12.82	2.27	2.77	24.51	19.84
34	ARMOUR SQUARE	2.92	7.50	12.72	15.98	12.29	46.69
35	DOUGLAS	15.48	19.03	3.91	20.85	27.03	0.00
36	OAKLAND	31.75	27.56	0.00	7.22	6.84	0.00
37	FULLER PARK	2.25	2.05	21.67	13.86	1.23	58.27
38	GRAND BOULEVARD	19.09	15.39	6.03	42.29	3.48	0.00
39	KENWOOD	22.41	19.11	0.00	37.15	2.74	0.00
40	WASHINGTON PARK	17.95	14.77	16.37	24.63	12.89	0.00
41	HYDE PARK	24.37	22.38	0.00	18.01	12.95	0.00
42	WOODLAWN	17.08	15.39	5.89	34.61	12.68	0.00
43	SOUTH SHORE	18.70	17.21	9.94	38.28	1.54	0.00
44	CHATHAM	8.69	3.28	30.99	49.49	5.37	0.00
45	AVALON PARK	11.12	6.41	44.48	34.00	0.87	0.00
46	SOUTH CHICAGO	7.84	3.74	11.12	24.52	1.86	48.20
47	BURNSIDE	1.56	3.66	74.49	17.85	1.22	0.00
48	CALUMET HEIGHTS	4.25	1.75	14.59	23.94	0.46	54.01
49	ROSELAND	7.81	3.43	13.14	70.39	3.00	0.00
50	PULLMAN	1.46	1.69	81.07	8.35	6.72	0.00
51	SOUTH DEERING	5.74	5.81	38.86	9.06	5.46	29.80

52	EAST SIDE	8.08	7.72	5.85	15.03	0.55	55.63
53	WEST PULLMAN	4.61	1.99	28.71	57.14	2.68	3.86
54	RIVERDALE	6.25	6.09	72.89	7.51	1.89	0.00
55	HEGEWISCH	4.48	4.49	35.99	14.98	2.46	33.44
56	GARFIELD RIDGE	5.23	3.18	19.02	49.49	21.43	0.00
57	ARCHER HEIGHTS	2.95	3.84	56.37	32.82	3.20	0.00
58	BRIGHTON PARK	4.45	4.19	58.94	29.65	2.44	0.00
59	MCKINLEY PARK	3.08	3.94	11.95	22.25	1.72	54.87
60	BRIDGEPORT	3.07	1.75	9.14	21.99	4.24	59.17
61	NEW CITY	6.83	5.66	14.94	32.74	2.82	34.49
62	WEST ELSDON	4.82	2.60	18.48	44.98	27.27	0.00
63	GAGE PARK	8.48	4.88	13.04	64.72	6.82	0.00
64	CLEARING	5.50	1.80	1.13	49.28	24.02	16.87
65	WEST LAWN	11.87	7.22	0.29	53.16	2.34	17.99
66	CHICAGO LAWN	13.44	7.80	3.08	45.87	3.46	19.44
67	WEST ENGLEWOOD	8.16	6.45	8.65	65.53	4.72	3.53
68	ENGLEWOOD	7.65	5.53	12.43	68.98	3.58	0.00
69	GREATER GRAND CROSSING	9.10	5.96	22.86	57.95	2.09	0.00
70	ASHBURN	12.18	6.95	1.96	48.87	4.86	18.49
71	AUBURN GRESHAM	11.51	7.27	8.64	55.97	2.44	7.96
72	BEVERLY	10.53	7.71	0.26	73.44	0.90	0.00

73	WASHINGTON HEIGHTS	6.08	3.67	4.59	82.33	1.57	0.00
74	MOUNT GREENWOOD	3.95	1.57	0.04	89.13	4.11	0.00
75	MORGAN PARK	7.65	2.72	3.96	81.77	2.17	0.00
76	OHARE	11.69	11.11	2.25	16.95	46.90	0.00
77	EDGEWATER	23.77	17.63	0.16	38.99	3.26	0.00

Table 9.1.; Neighborhood Area Zoning Distribution

Area Nº	Neighborhood	zone 7 %	zone 8 %	zone 9 %	zone 10 %	zone 11 %	zone 12 %
1	ROGERS PARK	0.00	0.00	0.00	0.00	0.00	5.01
2	WEST RIDGE	0.00	0.00	0.00	0.00	0.09	7.42
3	UPTOWN	0.00	0.00	0.00	0.00	0.00	18.85
4	LINCOLN SQUARE	0.00	0.00	0.00	0.00	0.23	6.20
5	NORTH CENTER	0.00	0.00	0.00	0.00	0.00	3.03
6	LAKE VIEW	0.00	0.00	0.00	0.00	0.00	18.41
7	LINCOLN PARK	0.00	0.00	0.00	0.00	0.08	16.38
8	NEAR NORTH SIDE	8.72	4.37	1.00	0.18	0.00	16.74
9	EDISON PARK	0.00	0.00	0.00	0.00	0.43	1.24
10	NORWOOD PARK	0.00	0.00	0.00	0.00	0.13	12.41
11	JEFFERSON PARK	0.00	0.00	0.00	0.00	0.00	14.08
12	FOREST GLEN	0.00	0.00	0.00	0.00	0.00	18.54

13	NORTH PARK	0.00	0.00	0.00	0.00	0.00	18.97
14	ALBANY PARK	0.00	0.00	0.00	0.00	0.00	10.39
15	PORTAGE PARK	0.00	0.00	0.00	0.00	0.00	1.89
16	IRVING PARK	0.00	0.00	0.00	0.00	0.00	3.49
17	DUNNING	0.00	0.00	0.00	0.00	0.00	1.58
18	MONTCLARE	0.00	0.00	0.00	0.00	0.33	2.37
19	BELMONT CRAGIN	0.00	0.00	0.00	0.00	0.10	1.94
20	HERMOSA	0.00	0.00	0.00	0.00	0.05	1.15
21	AVONDALE	0.00	0.00	0.00	0.00	0.00	2.60
22	LOGAN SQUARE	0.00	0.00	0.00	0.00	0.61	0.90
23	HUMBOLDT PARK	0.00	0.00	0.00	0.00	0.45	5.47
24	WEST TOWN	0.01	0.88	0.00	0.25	0.40	5.38
25	AUSTIN	0.00	0.00	0.00	0.00	0.09	3.78

26	WEST GARFIELD PARK	0.00	0.00	0.00	0.00	0.00	7.33
27	EAST GARFIELD PARK	0.00	0.00	0.00	0.00	0.00	7.13
28	NEAR WEST SIDE	6.07	3.33	0.00	6.34	0.00	0.80
29	NORTH LAWNDALE	0.00	0.00	0.00	0.00	0.00	4.98
30	SOUTH LAWNDALE	0.00	0.00	0.00	0.00	0.00	1.62
31	LOWER WEST SIDE	0.00	0.00	0.00	0.00	0.00	1.53
32	LOOP	12.14	8.71	0.00	3.38	0.00	13.22
33	NEAR SOUTH SIDE	6.28	0.00	1.00	3.59	0.03	11.89
34	ARMOUR SQUARE	0.00	0.00	0.00	0.00	0.22	1.68
35	DOUGLAS	0.00	0.00	0.00	0.00	0.16	13.53
36	OAKLAND	0.00	0.00	0.00	0.00	0.00	26.64
37	FULLER PARK	0.00	0.00	0.00	0.00	0.02	0.65
38	GRAND BOULEVARD	0.00	0.00	0.00	0.00	0.00	13.73

39	KENWOOD	0.00	0.00	0.00	0.00	0.00	18.60
40	WASHINGTON PARK	0.00	0.00	0.00	0.00	0.00	13.39
41	HYDE PARK	0.00	0.00	0.00	0.00	0.00	22.29
42	WOODLAWN	0.00	0.00	0.00	0.00	0.00	14.35
43	SOUTH SHORE	0.00	0.00	0.00	0.00	0.01	14.32
44	CHATHAM	0.00	0.00	0.00	0.00	0.31	1.86
45	AVALON PARK	0.00	0.00	0.00	0.00	0.00	3.11
46	SOUTH CHICAGO	0.00	0.00	0.00	0.00	0.00	2.72
47	BURNSIDE	0.00	0.00	0.00	0.00	0.00	1.22
48	CALUMET HEIGHTS	0.00	0.00	0.00	0.00	0.00	1.00
49	ROSELAND	0.00	0.00	0.00	0.00	0.00	2.23
50	PULLMAN	0.00	0.00	0.00	0.00	0.00	0.70
51	SOUTH DEERING	0.00	0.00	0.00	0.00	0.00	5.27

52	EAST SIDE	0.00	0.00	0.00	0.00	0.00	7.14
53	WEST PULLMAN	0.00	0.00	0.00	0.00	0.00	1.01
54	RIVERDALE	0.00	0.00	0.00	0.00	0.00	5.36
55	HEGEWISCH	0.00	0.00	0.00	0.00	0.00	4.17
56	GARFIELD RIDGE	0.00	0.00	0.00	0.00	0.00	1.65
57	ARCHER HEIGHTS	0.00	0.00	0.00	0.00	0.00	0.81
58	BRIGHTON PARK	0.00	0.00	0.00	0.00	0.00	0.32
59	MCKINLEY PARK	0.00	0.00	0.00	0.00	0.00	2.19
60	BRIDGEPORT	0.00	0.00	0.00	0.00	0.00	0.64
61	NEW CITY	0.00	0.00	0.00	0.00	0.00	2.52
62	WEST ELSDON	0.00	0.00	0.00	0.00	0.00	1.86
63	GAGE PARK	0.00	0.00	0.00	0.00	0.00	2.06
64	CLEARING	0.00	0.00	0.00	0.00	0.00	1.40

65	WEST LAWN	0.00	0.00	0.00	0.00	0.00	7.12
66	CHICAGO LAWN	0.00	0.00	0.00	0.00	0.00	6.91
67	WEST ENGLEWOOD	0.00	0.00	0.00	0.00	0.00	2.96
68	ENGLEWOOD	0.00	0.00	0.00	0.00	0.00	1.84
69	GREATER GRAND CROSSING	0.00	0.00	0.00	0.00	0.00	2.04
70	ASHBURN	0.00	0.00	0.00	0.00	0.05	6.63
71	AUBURN GRESHAM	0.00	0.00	0.00	0.00	0.00	6.20
72	BEVERLY	0.00	0.00	0.00	0.00	0.03	7.13
73	WASHINGTON HEIGHTS	0.00	0.00	0.00	0.00	0.00	1.76
74	MOUNT GREENWOOD	0.00	0.00	0.00	0.00	0.00	1.20
75	MORGAN PARK	0.00	0.00	0.00	0.00	0.00	1.73
76	OHARE	0.00	0.00	0.00	0.00	0.00	11.10
77	EDGEWATER	0.00	0.00	0.00	0.00	0.12	16.08

Table 9.2.; Neighborhood Area Zoning Distribution

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