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A Health Impact Assessment of Mixed Use Redevelopment Nodes and Corridors in Lincoln, Nebraska

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A HEALTH IMPACT ASSESSMENT OF MIXED USE REDEVELOPMENT NODES AND CORRIDORS
IN LINCOLN, NEBRASKA
By

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A HEALTH IMPACT ASSESSMENT OF MIXED USE REDEVELOPMENT NODES AND CORRIDORS
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Obesity is a growing threat to America's health. The national rate of obesity is 34% (Health Consequences, 2011), and Lincoln, Nebraska is not far behind that trend at 20.7% (BRFSS, 2011). Increasing physical activity is one way to reduce weight gain, (Edwards, 2008) and further studies show that small changes to the built environment can induce people to use alternative and more active forms of transportation such as biking, walking, and public transportation (Edwards, 2008; Zheng, 2008). The 2040 Comprehensive Plan for Lincoln, NE includes language to create a more walkable community. The proposal is to redevelop existing areas within city limits to create nodes of mixed land use with corridors of streamlined alternative transportation to connect those nodes. The nodes and corridors proposal was analyzed using a Health Impact Assessment (HIA) to determine whether the proposed changes will truly generate health benefits in Lincoln. Based on the walkability index developed by Frank, et al. (2004) and projected data for 2040, walkability was found to increase in all three study areas, compared to present conditions. These projected increases in walkability reasonably suggest that health benefits can be realized in the Lincoln community by following the changes proposed in the 2040 Comprehensive Plan.

Table of Contents

Introduction

The Lincoln and Lancaster County Comprehensive Plan for 2040, also known as LPlan 2040, was an effort by the Planning Department to create a 30-year comprehensive plan for Lincoln and Lancaster County in Nebraska. At the time this proposal was written, the plan was under public and committee review, and thus was considered a draft plan.

This planning process occurs every ten years, with smaller-scale updates in between, and provides a road map for the community to follow in order to reach its goals of creating a livable community. One goal it expresses is achieving a pattern of land use that promotes and protects public health. This goal is based on the Healthy Community statement provided in the plan:

"Urban design encourages walking and bicycling which improve environmental and physical   health. Neighborhoods are friendly to pedestrians, children, bicycles, the elderly and people   with disabilities" (Comprehensive Plan)

Both fields of Public Health and Environmental Health support this statement. Public health is the science of keeping the community as a whole healthy through both preventive measures and treatment strategies. Environmental health is a related field that seeks to improve the health of the community through improving the environments with which we come into contact and which can potentially make us sick.

For instance, improving water quality to reduce waterborne illness would fall under environmental health. Though sometimes overlooked, public health and environmental health are key components of a vital community. Combining concepts from public health, environmental health, and urban design in plans for the future, as noted in the Healthy Community Statement, can improve the well-being of the entire community. How could this work in Lincoln? A concept introduced in the Comprehensive Plan, of Mixed Use Redevelopment Nodes and Corridors, contains elements of Planning that have been shown in many studies to support public and environmental health. The Nodes part of the idea is centered on creating

hubs in the community that provide the major necessities, such as groceries, housing, and retail, in slightly higher densities and ensuring these hubs are well-integrated with the surrounding community. This enables residents to live, work, and play within walking and biking distance, reducing the use of cars.

Imagine being within walking distance of groceries and basic retail needs instead of having to drive to a major intersection or retail establishment where walking would be difficult and dangerous. With the Nodes and Corridors concept, not only would health be improved through physical activity, but air pollution would also be reduced as a result of reduced driving. Figure 1 below shows a hypothetical example of what a node could look like in Lincoln. This particular node is on P Street around 68th Street and will be analyzed in this study. The Corridor part of the Comprehensive Plan deals with transportation and supports the Nodes by linking them together using major transportation passages, such as arterial streets. In the case of Figure 1, the Corridor is O Street. Focusing on these identified corridors would promote higher levels of public transit services, as well as access for pedestrians and bicyclists in addition to the already active automotive traffic. Figure 2 below shows the Nodes and Corridors that have been identified in the Comprehensive Plan.

An architect's depiction of the Mixed Use Redevelopment Nodes and Corridors Concept, Looking West along P Street at about 68th Street

Figure 1. Depiction of a commerical Node around 68th and P. Taken from the 2040 Comprehensive Plan.
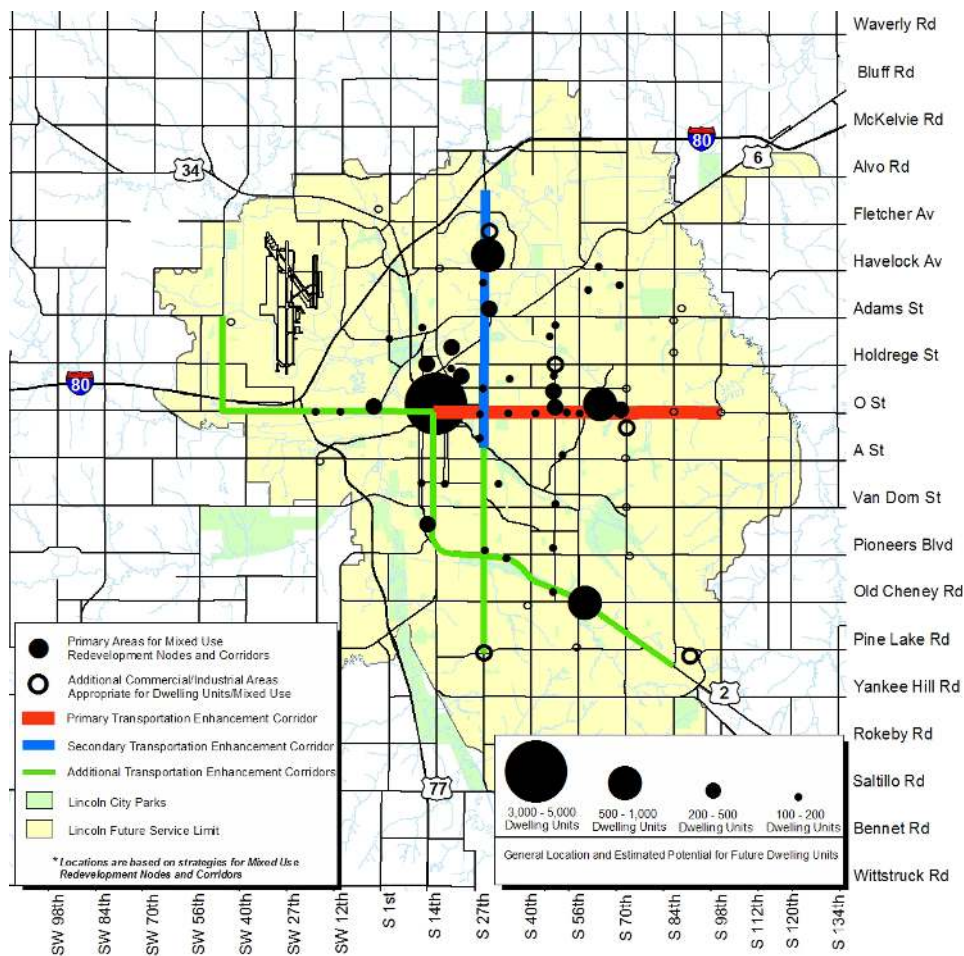
Literature Review

A growing threat to maintaining Lincoln, Nebraksa's status as a health community is obesity. Obesity has been a growing health problem over the years, and has even been called a current epidemic. The standard definition of obesity is having a Body Mass Index, or BMI, of 30 or above. The forerunner to obesity is overweight, which is defined as having a BMI of 25-29. Both physical conditions are well documented and followed by researchers and health professionals alike.

Many publications discuss the rising trend, possible causes, and solutions to remedy this "epidemic". Ward-Smith (2010) quotes a 74% increase in obesity cases from 1991 to 2001 in America, and that trend has not slowed down. In Lincoln, NE, 33.5% of the population is

considered overweight and 20.7% is considered obese, according to the Behavioral Risk Factor Surveillance System, which is coordinated by the Centers for Disease Control (CDC).

The National rate in the United States is around 34% overweight and 34% obese (Obesity and Overweight, 2010). Studies show that as a person gains weight to the level of being overweight or obese, the risk for contracting other chronic illnesses such as heart disease, type 2 diabetes, cancers, and hypertension, among many others, also increases (Health Consequences, 2011).

The economic impacts of obesity have also been examined. The CDC reports medical care costs related to obesity to be around $147 billion annually (Economic Consequences, 2011). Clearly, these costs are enormous from both a health and economic perspective.

Many factors contribute to increasing weight including diet, behavior, genetics, and physical activity. Physical activity is chosen for this study due to the amount of research that has been done on the relationship between physical activity, obesity, and environment. Further, the Nodes and Corridors concept presented in the Comprehensive Plan emulates this research by arranging the built environment to encourage physical activity and consequently reduce the risk of obesity.

For a healthy lifestyle, the CDC recommends 150 minutes of moderate aerobic activity and 75 minutes of intense aerobic activity per week for adults (CDC, 2008). In this case, moderate and intense aerobic activity are based on the heart rate reached and maintained in the activity. Americans, however, have increasingly sedentary and busy lifestyles that do not promote physical activity.

In the past, physical activity was incorporated into daily routines through activities such as walking or biking to school. Shops were also located closer to residential areas and cars were not as accessible. Over time, this context has changed as urban sprawl and zoning segregated by use became the trend. Cars were increasingly needed to get to school, work, and other activities. Figure 3 below shows the vehicle miles traveled (VMT) in a year ranging from

1956 to 2008. Not only does this arrangement increase dependency on cars, but also alienates those who may not have direct access to a car (elderly, disabled, youth, etc.).
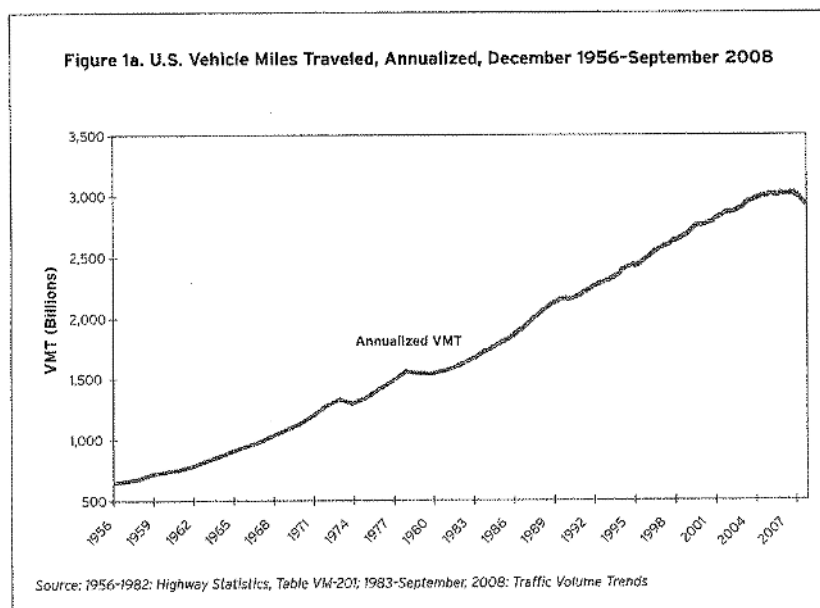

Figure 1a. U.S. Vehicle Miles Traveled, Annualized, December 1956–September 2008

Source: 1956-1982: Highway Statistics, Table VM-201; 1983-September, 2008: Traffic Volume Trends

Figure 3. Vehi ... Tomer 2008).

As time spent in cars has increased, so has risk of obesity. One study found a 6% increase in likelihood of obesity associated with each hour per day spent in a car (Frank, Anderson, & Schmid, 2004). Conversely, that same study found a 4.8% reduction in risk of obesity attributable to each kilometer walked per day (Frank, Anderson, & Schmid, 2004). In an additional study, incorporating walking and cycling into a commute was associated with an 11% reduction in cardiovascular risk (Hamer, 2008), and a study of Australian men further found that those who cycled to work were 21% less likely to become obese than those who drove to work (Zheng, 2008).

Changes to the built environment can promote physical activity by encouraging alternative modes of transportation. Frank, Anderson, and Schmid found that land-use mix has a strong correlation with obesity risk. They found a 12.2% reduction in obesity risk for every 5% increase in land use mix as defined by factors such as residential density, intersection density, number of land uses, and floor to area ratio (2004). Examples of changing the built environment

include improving the attractiveness and safety for pedestrians and cyclists as well as increasing public transportation options. Even though public transit is a motorized and sedentary form of transporation, it does have health benefits. Public transit is associated with 8.3 minutes of extra walking per day, or expenditure of 30 extra Calories/day (Edwards, R. 2008), due to walking to and from the bus stop. Considering that it is estimated that it would only take 100 extra Calories/day to stop the increase of obesity in 90% of the population (Edwards, R. 2008), utilizing public transit can make a significant contribution in the fight against obesity. Another study reported that men in Australia who took public transit to work were 16.2% less likely to become obese than those who drove (Zheng, 2008).

This study prosposes to examine the Nodes and Corridors concept as presented in the Comprehensive Plan. A data available from the Planning Department and County Assessor will be used in a model that can estimate the potential health impacts from increasing mixed use development. The results will be comprehensive and can be used to evaluate future projects and developments in Lincoln for their potential health impacts. The following section will describe the methods that will be used to perform this study.

Materials and Methods

The process used to perform this study will be a Health Impact Assessment. An HIA is a "combination of procedures, methods and tools by which a policy, program or project may be judged as to its potential effects on the health of a population, and the distribution of those effects within the population" (WHO 1999).

The process of completing an HIA is fairly standard across disciplines. The major steps are

1. Screening – identifying a relevant project to assess
2. Scoping – identifying key aspects of the project to determine which points need to be addressed
3. Profiling – identifying key characteristics of the population that can be used to determine results
4. Assessment – gathering the data and completing the analysis

5. Report and Evaluation – communicating findings and evaluating the the effectivness of the HIA

The Screening and Scoping processes were completed for two proposed projects - determine the impacts of the relocation of a major employer within the city and determine the impacts of increasing mixed used development. Based on the goals of LLCHD and the timing of this project, it was decided to complete an HIA on the Nodes and Corridors Concept (see Appendix A for more information on the Screening process). Specifically, the three nodes to be analyzed will be along O St. between Cotner and 70th, as mentioned in the introduction, and the area north of Folkaways Blvd. between N. 27th and N. 33rd, and the area Norheast of the intersection at S. 56th and Highway 2 (See Appendix B for more information on the Scoping process).

The three nodes identified were analyzed using a walkability index model developed by Frank, et al. (2006). The model compares the following four components:

Land Use Mix – ratio of land uses/area
Residential Density – ratio of housing units/area
Retail Floor to Area Ratio – ratio of retail floor space to land area used for the buildings
Intersection Density – ratio of intersections/area; represents connectivity within an area
  -see Appendix C for a complete description of the model

The walkability index was calculated for each Traffic Analysis Zone (TAZ) in Lincoln. Lincoln is divided into around 300 TAZ's, which are smaller units of area used to analyze various aspects of planning, such as transportation. The Planning Department keeps many of their records in terms of TAZ's, so it was determined to continue with TAZ's in order to facilitate use of the results. Each node identified earlier corresponds with specific TAZ's as detailed in Appendix B.

The data for this study was gathered in two different datasets – one from County Assessor records and one from Planning Department records. The county assessor records have parcel level data with very specific land use classifications along with other data, allowing for a more accurate walkability calculation from the model used in this study. On the other hand, this data cannot be easily or accurately projected into the future, which is required for this study.

The data from the Planning Department can and has been projected by consultants to various intervals (2025, 2030, and 2040), but in order to reduce error, the projections have very general land use classifications. For example, where the County Assessor data can be broken down into the four land use categories required by the model, the Planning dataset can only be broken down into three, which reduces the model's ability to accurately calculate the walkability index of the study areas. Further, the datasets from both departments cannot be mixed due to the methods each uses to classify land use.

To take advantage of the strengths of both of these datasets, a present day walkability index was calculated using the County Assessor data. This is a strong model that can be easily calculated in the future to track changes in walkability over time. In order to calculate expected changes in walkability by 2040 for this study, the Planning data was used to calculate the walkability index. A 2011 index was calculated for all of Lincoln, and then the 2040 index for the three identified nodes was calculated using projected data provided by the Planning Department. The change in index between 2011 and 2040 in the identified nodes was used for the analysis to determine whether mixed use redevelopment in the form of nodes can generate positive health impacts.

The determination of whether benefits will be realized through the nodes and corridor plan was based on the study behind the model used, which took place in King County, WA. It found several benefits to be directly related to a 5% increase in the walkability index of an area including reduced Body Mass Index (BMI), increased time spent in physical activity, reduced air pollution, etc. (Frank, et al. 2006). It was determined that this model should be used to estimate potential health impacts instead of collect real data on Lincoln due to the large amount of time and resources required to complete that process. As a preliminary analysis tool to determine whether the nodes and corridors concept could be beneficial to public health in Lincoln, this peer-reviewed model is sufficient.

Results

As described before, the County Assessor dataset was used to calculate walkability for each TAZ in Lincoln for 2011. The following map shows the results across Lincoln. These results will be provided for future reference and interested departments in Lincoln, NE will have the tools available to continue calculating this measure at any desired interval to track how walkability changes in Lincoln.
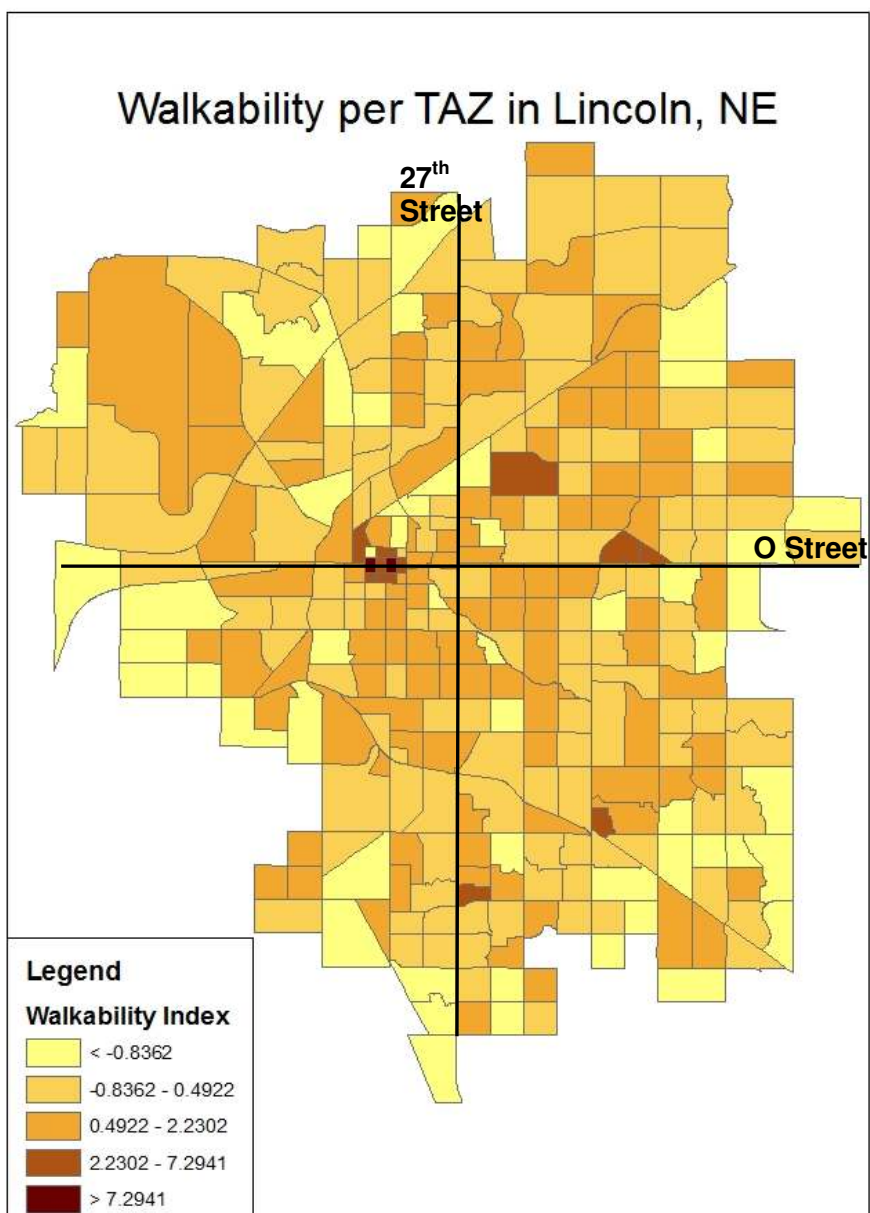

Figure 4. Walkability by TAZ in Lincoln, NE for 2011 based on County Assessor Data.

In this index, higher scores equate to an environment that is more walkable and lower scores to an environment that is less walkable. As the map shows, the area with the highest walkability in Lincoln is downtown. A few other areas of medium walkability are scattered around Lincoln, but most of Lincoln has low walkability. This map and related data will be available to the Planning department to aid in decision-making.

Using the Planning Department's dataset, the walkability index was calculated for each TAZ in Lincoln for 2011 and 2040 as described in the previous section. This measure was used to project the change in walkability as a result of mixed use redevelopment projects in the identified nodes. The following table displays the projected change in walkability index for those nodes. As with the previous example, higher indices relate to better walkability.

Node	2011 Index	2040 Index	% Change
O Street	-0.9191	1.2275	234%
N. 27th	-2.0774	-1.7442	16%
S. 56th	-0.9872	8.3501	946%

Table 1. Projected change in walkability index per node.

The results show an increase in walkability in all three identified nodes.

Discussion

The results of the walkability index calculated with County Assessor data for 2011 makes sense within the scope of Lincoln. Most of Lincoln is made up of low density development. As Figure 4 shows, the Downtown area is the one outlier in terms of walkability, and as this is the only densely developed area in Lincoln, this result was expected. The index for that area was calculated at 22 where most of the other TAZ's have an index between -1 and 1. This result lends further credibility to the model and data used.

The model shows that mixed use redevelopment in the identified nodes will generate an increase in walkability. On the other hand, the increase for the O Street and S. 56th nodes was identified as being extreme. Upon further investigation, it was determined that this was due to

the projected increase in residential density of the nodes. Even should projections of such high density residential land use be over-estimated, since no residential units are currently located in this node and 659 residential units are planned for in the 2040 Comprehensive Plan, any growth in residential density in these nodes will lead to an increase in walkability.

Another major finding is that since the mixed use redevelopment nodes are projected to increase walkability by well over 5%, it can be expected that Lincoln will, at minimum, see the following benefits per capita (Frank, et al., 2006):

1. a 32.1% increase in time spent in physically active travel
2. 0.23-point reduction in body mass index
3. 6.5% fewer vehicle miles traveled

Many studies demonstrate the health benefits of increased time spent being physically active and BMI reductions, but due to all the variables involved, it is difficult to quantify specific benefits. The following two benefits were identified by additional studies on physical activity and BMI reduction. One study found that the 32.1% increase in time spent in physically active travel would contribute to up to a 50% reduction in incidence of colon cancer (Colditz, 1997). Another study showed that a 0.23 reduction in BMI would translate to about 1.6 pounds lost (based on 69.7 inches, the average height of men in the United States; Halls, S. 2008; BMI Formula). This rate of weight loss, if it can be maintained for 10 consecutive years relates to about a 33% reduction in risk of diabetes for a subsequent 10 years (Resnick, 2000).

Lincoln will also likely see the following improvements in air pollution based on the increase in walkability (Frank, et al., 2006):

4. 5.6% fewer grams of oxides of nitrogen (NOx) emitted
5. 5.5% fewer grams of volatile organic compounds (VOC) emitted

These benefits will be attributable to the whole of Lincoln's population, but children and seniors will be most affected.

A higher than average percentage of seniors currently live in the O Street and S. 56th St. nodes, according to the American Community Survey (5-year estimates 2005-2009), and will

be positively affected by the greater access to public transportation, reduction in air pollution, and more opportunities to be physically active. Children will benefit from the same factors. A growing number of children in Lincoln are overweight and obese which is a growing concern for their future health. Pursuing mixed use redevelopment in the identified nodes will improve the conditions for children and make living a healthy lifestyle easier. Appendix D can be referenced for an in-depth look at how mixed use redevelopment can benefit these two vulnerable populations.

Because the study this model is based on was conducted in King County, WA, it is important to take human behavior into account. The populations and other conditions are not exactly equal between Lincoln and King County. Appendix E contains a detailed discussion on behavior change and how to implement mixed use redevelopment in Lincoln with acceptance by the public and participation in more physically active forms of transportation. Beyond behavior change, a study by Mumford, et al. (2011) was designed to eliminate the influence of human behavior and thus their results show the effects the built environment has on decisions to participate in active transportation and physical activity. This study showed that by moving from a lower density neighborhood to a dense, mixed use development, residents showed a 46-54% increase in walking for fitness after moving and a 44-84% increase in walking for transportation after moving

Conclusion

The results of this study project that an increase in walkability can be achieved through mixed use redevelopment as described in the 2040 Comprehensive Plan for Lincoln and Lancaster County Nebraska. The benefits per capita will be at least:

1. a 32.1% increase in time spent in physically active travel
2. 0.23-point reduction in body mass index
3. 6.5% fewer vehicle miles traveled

As well as the following reductions in air pollution:

6. 5.6% fewer grams of oxides of nitrogen (NOx) emitted
7. 5.5% fewer grams of volatile organic compounds (VOC) emitted

All as described in the 2006 study by Frank, et al. These benefits will be realized in the

population as a whole, but elderly populations and children ages 5-14 years will benefit the

most. Additional literature supports this research through studies of human behavior and

impacts the built environment has on engagement in physical activity as exercise and/or as

transportation. Appendix E of this document should be referenced for additional information on

behavior change related to transportation.

Further study should include tracking of changes to walkability in Lincoln over time.

Additional work in evaluating changes in transportation behavior as a result of mixed use

redevelopment in Lincoln should also be considered.

Appendices

Appendix A
Summary of Findings
Screening of Potential HIA Projects

Objective:
Identify a project about which an HIA should be pursued.

Possible Projects:
1. Identify and evaluate the health impacts of pursuing the Nodes and Corridors concept identified in the Lincoln Comprehensive Plan for 2040.
2. Identify and evaluate the health impacts of the transportation and behavior changes made by employees of Company X as it changes location.

The screening exercise was based on a standard checklist from the University of California – Los Angeles Health Impact Assessment Project. It consists of a comprehensive list of public health components (water quality, transportation options, etc.) and a ranking system for the likelihood and degree to which the proposed project or policy could affect each component. A copy is attached in the following pages. After completing the exercise, it was determined that both proposed projects have fairly equal potential as HIA projects with the Nodes and Corridors plan having slightly more potential. Therefore I have created a Pros/Cons list for each.

Nodes Plan
Pros-   Cons-
-HIA has potential to affect future development   -More estimations/generalizations
        decisions for these nodes   will have to be made
-Wide population to be affected- including   - Results will be based on a model, not
actual
        disadvantaged populations   data from Lincoln citizens
- Diverse scenarios/impacts can be explored
-Would be based on a peer-reviewed model

Company X Plan
Pros-   Cons-
-Data will be representative of Lincoln   -Company X's move will occur after
-Will create a local database on   deadline for this project
        physical activity and behavior   -HIA has less potential to directly
                                                                                   affect a future decision (the
                                                                                   building has been built)
                                                                       -Small population affected

Based on this screening, completing an HIA on the Nodes and Corridors Concept shows the most overall potential, especially in consideration of the timeline of the Company X relocation. It would not be possible to collect data on the actual transportation changes made by the employees, just their expected changes. The Nodes and Corridors project also contains the possibility to explore more diverse scenarios and health impacts.

[For a copy of the checklist, please see accompanying attachment "Screening_Scoping_Checklist.pdf"]

Screening-Scoping
Checklist

Appendix B
Summary of Findings
Scoping of HIA Project

Objective: Define outcomes for the study
Process: Multiple meetings were conducted with representatives of the Planning Department, Brandon Garrett and David Cary. Through these discussions the following outcomes were defined.

1. Calculate walkability index for 2011 for all Traffic Analysis Zones (TAZ) in Lincoln

Rationale: Planning will be able to use this information when making decisions. They will also be provided with a way to calculate this index in the future and track progress over time.

2. Calculate walkability index for the TAZs included in the nodes identified by Planning for 2040 using projected data. Compare to 2011 index for an estimated change in walkability as a result of the node.

   a. Node: O St. between Cotner and 70th St
       Traffic Analysis Zones (TAZ) 47, 52, 241, 242
       Corridor: O St.

From GIS Development Viewer www.lincoln.ne.gov
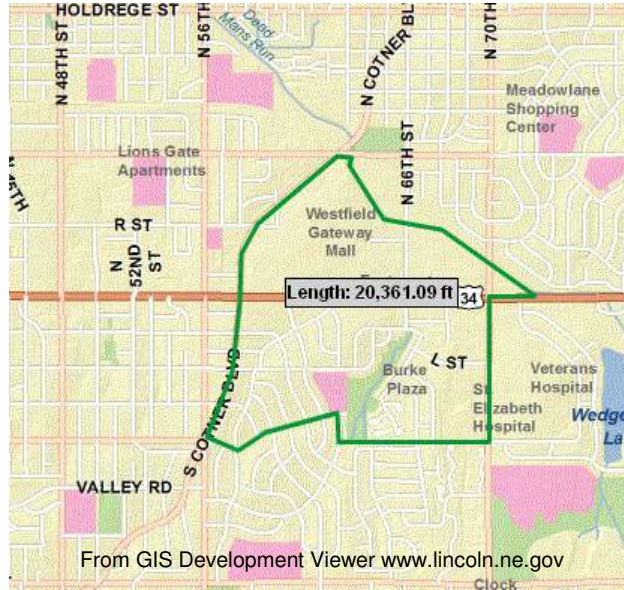
Rationale:
The O St. Node is identified in the Draft Comprehensive Plan for 2040 and is projected to receive the highest number of new dwelling units. A plethora of empty buildings and large parking spaces surrounded by multiple opportunities for alternate transportation, parks, and retail make a great place to analyze the potential impacts of node development. It also is located along a Transportation Corridor, improving the opportunities for alternative transportation. The Planning department identified this as a significant node for analysis

   b. Node: North of Folkaways Blvd between N. 27th and N. 33rd
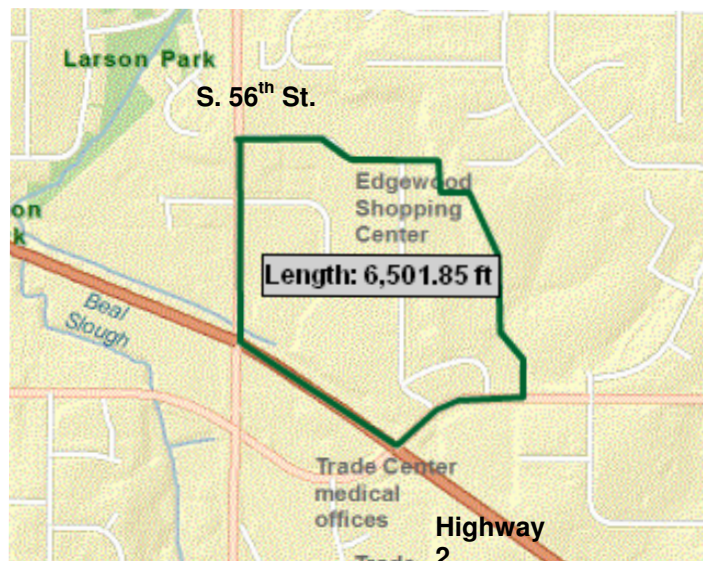   TAZ 261
       Corridor: N. 27th
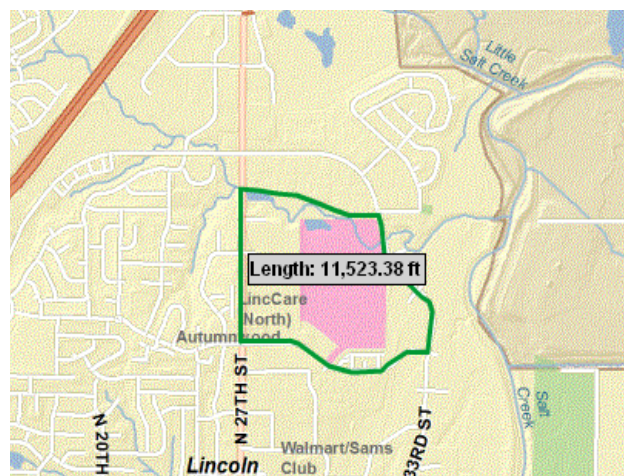
From GIS Development Viewer www.lincoln.ne.gov

Rationale:
The N. 27th St. Node is identified in the Draft Comprehensive Plan for 2040 and is projected to receive the second highest number of new dwelling units after the O St. Node. This area is relatively undeveloped. It includes North Star High School and is located next to a relatively dense residential area to the West. Finally, it is located along the N. 27th Corridor which will increase opportunities for alternative transportation. The Planning Department also identified this as a significant node for analysis.

    c. Node: Area Northeast of intersection at S. 56th and Highway 2
           TAZ 331

Larson Park

S. 56th St.

Edgewood Shopping Center

Length: 6,501.85 ft

Beal Slough

Trade Center medical offices

Highway 2

Trade

Rationale:

The S. 56th St. Nodes is identified in the Draft Comprehensive Plan for 2040 and is projected to receive the third largest number of new dwelling units. The Planning Department also identified this area as a significant node for analysis. This area is currently developed in commercial land use and does not contain any residential units. Highway 2 is also identified as a transportation corridor which will increase transportation options.

Appendix C
Discussion of Model Used in the Study

The model will be based on a walkability index developed by Frank, et al. (2006). The model consists of the following equation, which incorporates four components of the built environment:

$$L + R + FAR + 2(I)$$

(L) - Land Use Mix
(R) - Residential Density
(FAR) - Retail Floor to Area Ratio
(I) - Intersection Density

$L = A/(lnN)$
$A = (b1/a)*ln(b1/a) + b2/a*ln(b2/a) + \ldots b4/a*ln(b4/a)$
a = total acres of land for all 4 land uses
b1 = acres in Institutional uses (education, government)

b2 = acres in Residential use
b3 = acres in retail
b4 = acres in offices
N = number of 4 land uses with FAR > 0

R = # residential units / acres in residential use

FAR = retail building floor area / retail land area

I = # intersections / mi^2

The z-score of each component is calculated and then added together. The z-score is a standardization technique that allows different factors, such as the four included in this model, to be compared. As in the study by Frank, et al. (2006), intersection density is weighted twice as much as the other three components to underscore the importance of connectivity within an area. Based on the data available for Lincoln, the model may be modified, which will be documented in the final report.

The land use data will be gathered from the Planning Department and the County Assessor. A walkability index score for 2011 will be calculated for all TAZs in Lincoln. A score for 2040 will be calculated for the identified nodes. The change in index between 2011 and 2040 in the identified nodes will be analyzed to determine whether the development of nodes can generate positive health impacts. The study behind the model used, which took place in King County, WA, found the following benefits to be directly related to a 5% increase in the walkability score of an area:

 - a 32.1% per capita increase in time spent in physically active travel,
 - 0.23-point reduction in body mass index,
 - 6.5% fewer vehicle miles traveled,
 - 5.6% fewer grams of oxides of nitrogen (NOx) emitted,
 - 5.5% fewer grams of volatile organic compounds (VOC) emitted

By gathering data on existing conditions and projected conditions for 2040 in the five TAZ's identified above, it can be determined if at least a 5% increase in walkability can be achieved by pursuing development of the nodes and corridors. If such an increase can be achieved, the health benefits would justify the project.

Appendix D
Summary of Findings
Profile of Vulnerable Populations in Lincoln, NE

Objective: Identify key characteristics of the population that can be used to determine results.
Vulnerable populations are of particular interest.

After a short study of Lincoln's population, the most vulnerable populations identified were seniors and children. These two populations are the most vulnerable particularly with respect to access to transportation. They are the most likely to not have access to personal vehicles and/or the ability to operate vehicles. Thus, they rely on walking, public transportation, and ultimately other people to get them where they need to go. In addition, these populations are more susceptible to respiratory complications from air pollution. The following table shows the breakdown of these key populations in each node and shows how it compares to the Lincoln average.

Age Group	Lincoln	O Street Node	N. 27th St Node	S. 56th St Node
5-14 years	12.6%	11.8%	6.3%	12.6%
65+ years	10.9%	21.4%	6.3%	13.1%

Table 1. Breakdown of key populations in each node (Age and Sex, 2005-2009).

As the table shows, the O Street and 56th St. nodes have an above average population of seniors and an average population of children aged 5-14 years. The N. 27th St. node has a below average population of both seniors and children. While the presence of these vulnerable populations in any amount merits attention, the higher concentrations in these particular nodes reinforce the benefits that will be derived from mixed use redevelopment. Providing amenities such as greater access to public transportation, closer proximity between commercial and residential areas, greater opportunities for physical activity, improved air quality, etc. will improve the quality of life of these vulnerable populations.

In addition to dependence on others for access to resources and transportation, children in Lincoln are facing a new epidemic – obesity. The following figure shows the shocking trend now common in Lincoln children.

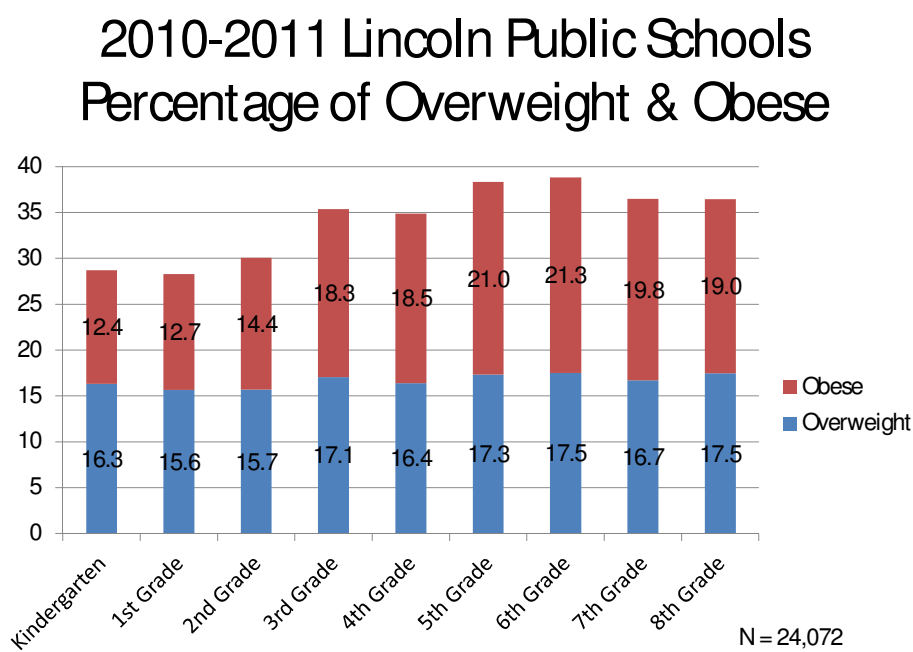## 2010-2011 Lincoln Public Schools Percentage of Overweight & Obese

Figure 1. Percentage of overweight and obese children by grade in Lincoln, NE public schools.

The graph shows that in each grade, even in kindergarten, the percentage of children that are overweight or obese is at least 28.4% (Rauner & Avery, 2011). These high numbers have serious implications for the future health of Lincoln, as obesity in childhood and particularly adolescence has been strongly linked to obesity in adulthood (Lester, 2011).

Further data from the American Community Survey for 2005-2009 report some travel behavior indicators that can be used to understand Lincoln's population. One revealing indicator is that the average number of people riding in personal vehicles per trip is around 1.07 for Lincoln, NE (Age and Sex, 2005-2009), or that most trips by car are taken alone. This represents a need to encourage trip-sharing behaviors that reduce the overall number of trips by car and reduces air pollution. Another indicator is the trip time to work. For Lincoln, the average is around 17 minutes (Age and Sex, 2005-2009), which indicates that residents are not living close to where they work. While many factors lead to this situation, pursuing mixed use

redevelopment would reduce this travel time by providing more residential options near places of work as well as increasing the opportunities to take public transportation.

Appendix E
Synthesis of Behavior-Change Literature Review

Method- 17 journal articles were found relating to behavior change relative to pro-environmental behavior and transportation behavior. The specific topics covered include impact of the built environment, decision-making, policy measures, and public transit behavior. The syntheses for each topic follow. These syntheses include explanations behind behaviors and suggestions for policies and other considerations to make before pursuing mixed use redevelopment projects. They are meant to supplement incorporation of mixed use redevelopment projects in Lincoln in order to increase acceptance by and participation of Lincoln residents.

Built Environment:

The relationship between the built environment and engagement in physical activity is complex, but the design of the built environment has a significant impact on people's decision to walk and engage in other types of physical activity. **The important factors include perceived safety, attractiveness, location**, etc. ("Does the Built . . .", 2005; Cervero, et al., 2009; Handy, et al., 2006).

Decision-making Components:

What Makes Someone Decide to Use Active Transportation Instead of Drive?
-Miscellaneous motivations and considerations related to transportation mode (Van Vugt, et al.,1996)
      - This could include reliability, timeliness, location, etc. of the mode, and usually 2 or more of these considerations factor into the decision of any given situation
-Past behavior and anticipated emotions (Carrus, et al., 2008)
      -A person's past actions along with the way they anticipate feeling while traveling strongly influence the person's immediate decision to drive or not
-Perceived mobility needs (Haustein & Hunecke, 2007)
      -Does the person need to transport children? Does the person need to make a lot of stops on the way to work? These varying needs can support or inhibit the intention to use alternative modes of transportation depending on the situation
-Personal ethics/morals (Nordlund & Garvill, 2003)
      -This determines a person's willingness to cooperate in social dilemma situations. For example, a person with a strong environmental ethic would change their travel mode to reduce air pollution for the greater good of society.
-Residential location and built environment (Cao, et al., 2009)

- A person's choice of residential location and the characteristics of the built environment determine travel behavior more than the individual's choice of travel mode alone. Thus, cities can use land-use policies to change travel behavior. For example, they can incorporate mixed use development, strategically locate residential areas and transit services close to each other, etc.

-Understanding man's dependence on the environment (Davis, et al., 2009)

-Those who understand man's dependence on the environment tend to exhibit pro-environmental behavior.

Other helpful points related to Decision-Making:

-It has been found that a gap is growing between people's intentions to help the environment and their actions. Efforts should be moved from general education to be more focused on determining the specific barriers residents face in acting on their intentions and helping to remove them (Huddart, et al., 2009).

-Women tend to have stronger ecological standards as well as less-developed car habits, thus they tend to be more easily convinced to change to different modes of transportation. On the other hand, safety is a big consideration for women, and they will rarely choose an unsafe mode of transportation if it can be helped (Matthies, et al., 2002).

-Community-based social marketing approaches have been found to successfully change travel behavior. King County in Washington has developed a successful and replicable program (Cooper, 2007).

Policy Measures:

Soft Policy measures such as incentives, information, tailored services, etc. could dramatically improve traffic choices and conditions, including decreasing personal car use by 15% (Cairns, et al., 2008; Möser & Bamberg, 2008). In addition, children learn travel behavior from their parents, which means that policy should treat transportation planning as a social construct and not simply as demand management (Baslington, 2008).

Public Transit Behavior:

In targeting behavior change methods towards getting more people to use public transit, it is important to remember that more than half of the determinants in bus ridership are outside of the transit program's control, such as geography, population demographics, etc. About the only determinants under the transit program's control are trip frequency (higher is better) and fare (lower is better) (Taylor, et al., (2008).

On the other hand, natural interventions can be used to promote a sustained shift to public transit. An example would be a program that provides information and feedback on alternative transportation options to people that have recently moved, both those who have recently arrived in the city and those that moved to a new residence within the city (Bamerg, 2006).

Appendix F
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