Spatial Patterns of End Stage Renal Disease and Selected Risk Factors, 2010 – 2012

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Abstract

Spatial analysis is used to determine spatial disparities in End Stage Renal Disease and selected cofactors. Spatial autocorrelation, hot spot and cluster analysis with rendering, and predictive modeling are used to quantify the level of uncertainty associated with ESRD, tobacco use and diabetes spatial patterns. High ESRD hospital discharges and deaths, diabetes and tobacco use were found to be collocated in certain zip codes. Inspite of rapid advances in available statistical tools, statistical testing of spatial data remains relatively rare, but provides support for evidence-based decision making.

Background

Chronic kidney disease affects 26 million Americans and affects about up to 25% of the United States population[4].

End-stage kidney disease is the complete or almost complete failure of the kidneys to function.

The five–year survival is less than 50 percent[2].

The complexity of ESRD involves the contribution of different underlying diagnoses to ESRD.

Zip codes 20002, 20022, and 20019 have the highest incidence of End Stage Renal Disease (ESRD) in the nation[3].

This provides the impetus to examine disparities in the geographic distribution of ESRD in the District.

Moreover, as a result of longer survival, the prevalence of ESRD is increasing but remains associated with a high mortality[13].

Background

Higher blood pressure and lower socioeconomic status have been associated with higher incidence of ESRD in black and white men[1, 8, 9].

ESRD incident rates are more than three times higher for African Americans than for Caucasians.

While unadjusted annual ESRD mortality patients are declining, total ESRD patient deaths are increasing.

Total of 3109 ESRD and diabetes cases, in which ESRD hospital discharges are the highest (Table 1).

Table 1: ESRD, ESRD Hospital Discharges and Mortality and Diabetes, 2008 - 2011

ESRD AND DIABETES	N	YEAR
ESRD HOSPITAL DISCHARGES	1503	2010 - 2011
END STAGE RENAL DISEASE	809	2008 - 2009
END STAGE RENAL DISEASE MORTALITY	268	2012
DIABETES	529	2011

Objectives

Determine disparities in the spatial distribution patterns of renal disease, smoking and diabetes in the District covering the period 2010 – 2012.

Quantify their spatial patterns to enhance evidence-based decision making.

Examine disparities in their spatial distribution patterns.

Examine spatial patterns of lifestage group characteristics to aid in targeted ESRD messaging.

Demonstrate the use of selected spatial tools for examining spatial patterns.

Figures 1 – 2: Spatial Pattern Analysis of ESRD Hospital Discharges and Dialysis Facilities, 2010 – 2012

Figure 1 shows hot spots of ESRD hospital discharges (red polygons) in wards 1, 2, 6 7 and 8 zip codes.

ESRD hospital discharge cold spots (blue polygon) are confined to ward 2 zip codes.

Figure 2 shows ESRD hospital discharge hot and cold spots are collocated with dialysis facilities.

Figure 2 also shows one or more dialysis facilities are collocated with ESRD hospital discharge hot spots.

On the other hand, fewer dialysis facilities (</ 1) are collocated with ESRD hospital discharge cold spots.

More dialysis facilities (>/ 1) are collocated with ESRD hospital discharge hot spots.

Figures 1 – 2: Spatial Pattern Analysis of ESRD Hospital Discharges and Dialysis Facilities, 2010 - 2012

Figure 1: Hot Spots of ESRD Hospital Discharges, 2010 - **2012**

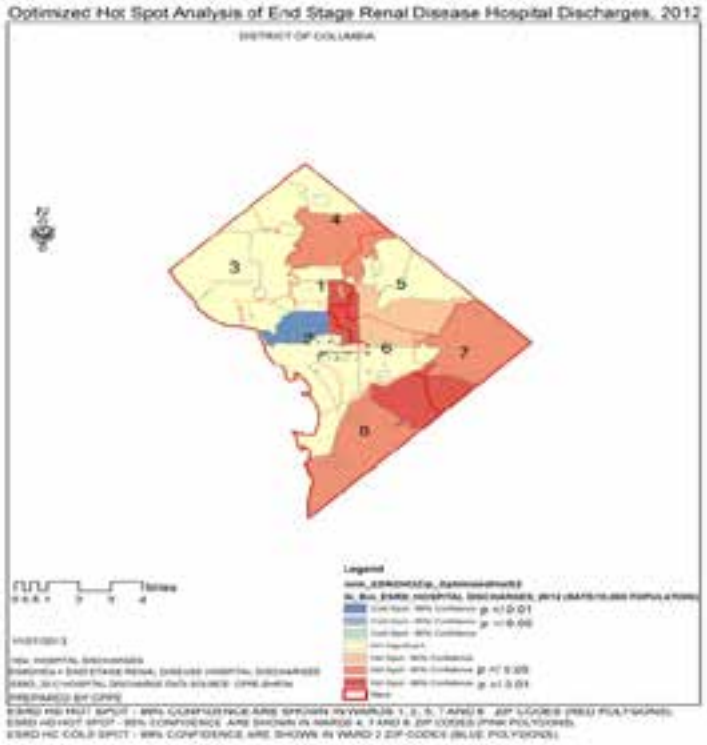
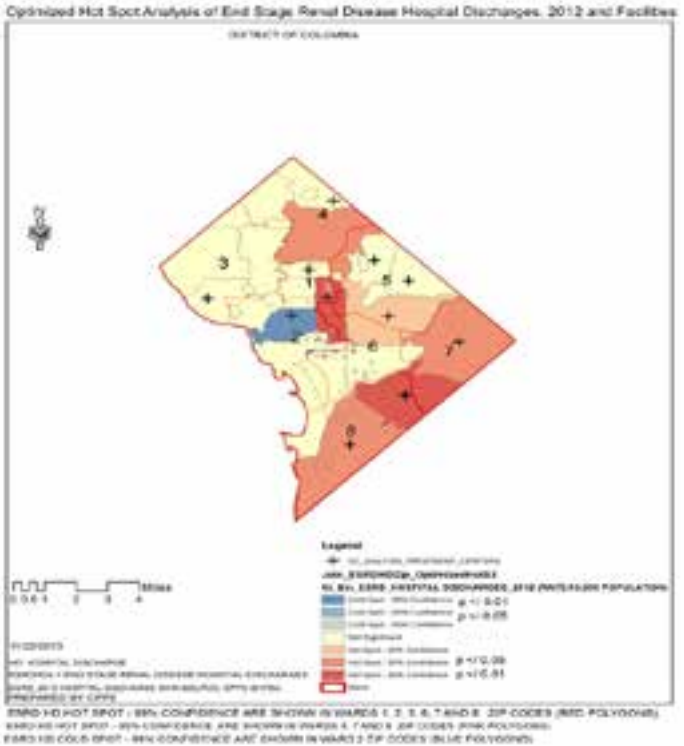


Figure 2: Hot Spots of ESRD Hospital Discharges and Dialysis Facilities, 2010 - 2012



Figures 3 – 4: Spatial Pattern Analysis of ESRD, ESRD Mortality and Dialysis Facilities 2010 – 2012

Hot spots of ESRD and ESRD mortality (red polygons) are collocated with dialysis facilities in wards 1, 2, 5 and 6 zip codes (Figures 3 – 4).

Zip codes in these wards show disproportionate distributions of ESRD hot spots (Figure 3).

Collocation of ESRD and ESRD mortality in Wards 1, 2, 5 and 6 demonstrates disparities in their spatial distribution patterns (Figures 3 – 4).

Figures 3 – 4 show ESRD and ESRD mortality hot spots are collocated with dialysis facilities.

Figures 3 – 4: Spatial Pattern Analysis of ESRD Hospital Discharges and Dialysis Facilities, 2010 - 2012

Figure 3: ESRD Hot Spots and Dialysis Facilities, 2010 - 2012

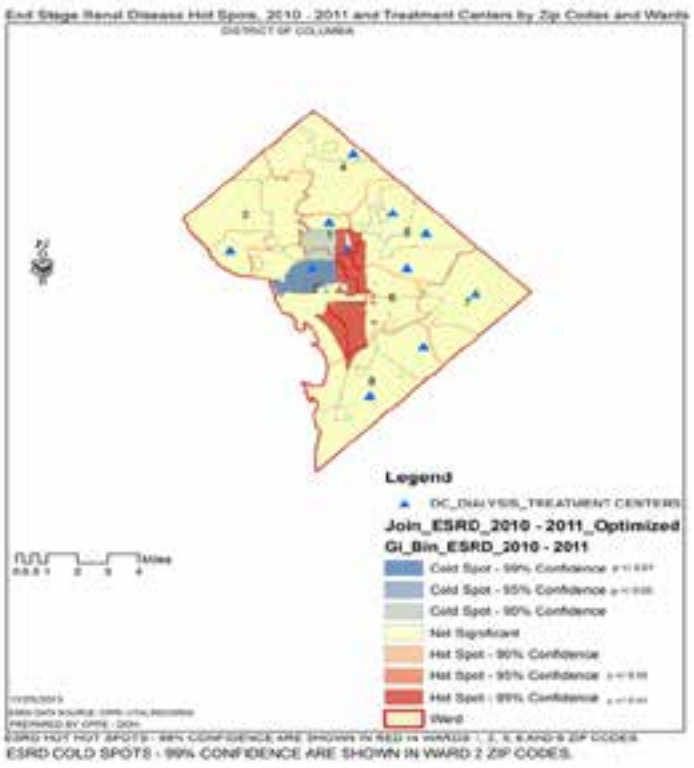
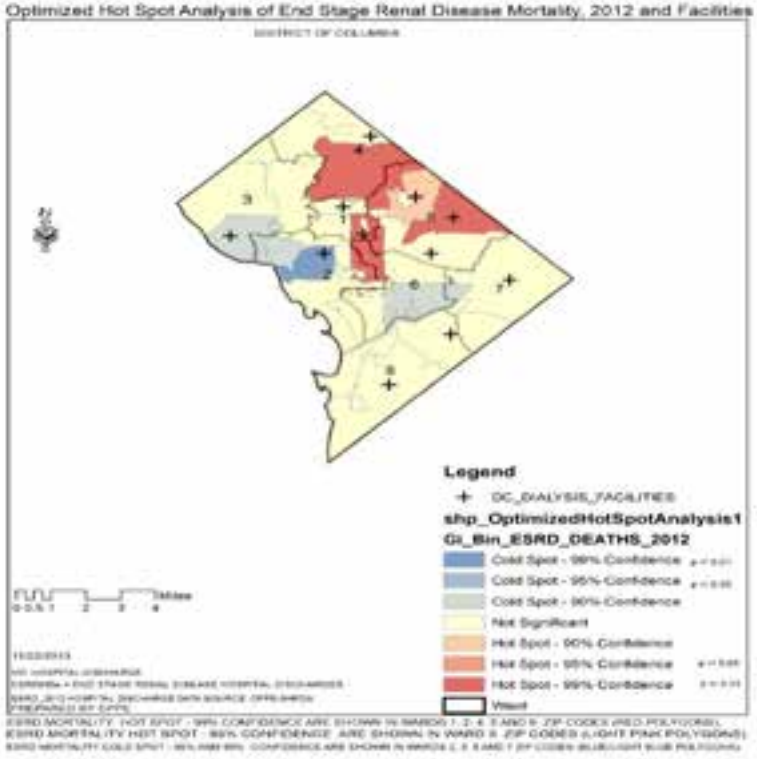


Figure 4: ESRD Mortality and Dialysis Facilities, 2010 - 2012



Figures 5 – 6: Spatial Patterns of The 65-plus Age Groups, ESRD Dialysis Facilities and Hospital Discharges

Overlays of the 65-plus age group, ESRD hospital discharges and diabetes are shown in Figures 5 – 7.

Highest composition of the 65-plus age group are shown as red polygons (12.6%) in wards 3, 4, 5, 6, 7 and 8 zip codes (Figure 5).

Lowest composition of the 65-plus age group are shown as blue polygons (0.7%) in ward 2 zip codes (Figure 5).

Highest ESRD hospital discharges, shown as green polygons (23.1%), are in close proximity to dialysis facilities (blue triangles) in wards 1, 5, 6, 7 and 8 zip codes (Figure 6).

Lowest ESRD hospital discharges, shown as white polygons (4.5%) are in close proximity to low number of dialysis facilities (blue triangles) and collocated in wards 2 and 3 zip codes (Figure 6).

ESRD dialysis facilities (blue triangles) and high ESRD hospital discharges (6.6% - 9.9%) are collocated in Wards 1, 5, 6, 7 and 8 zip codes (Figure 6).

Figures 5 – 6: Spatial Patterns of The 65-plus Age Groups, ESRD Dialysis Facilities and Hospital Discharges

Figure 5: The 65-plus Age Groups, 2013

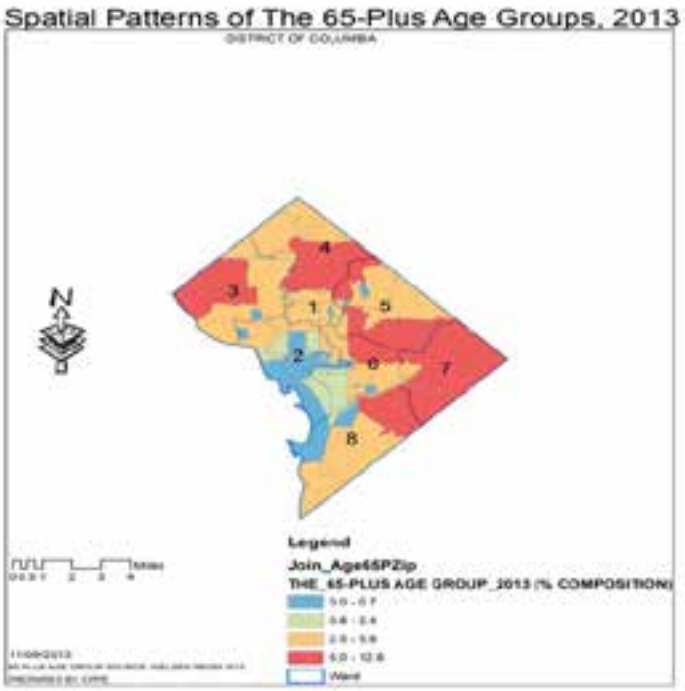


Figure 6: Dialysis Facilities and ESRD Hospital Discharges, 2010 - 2011

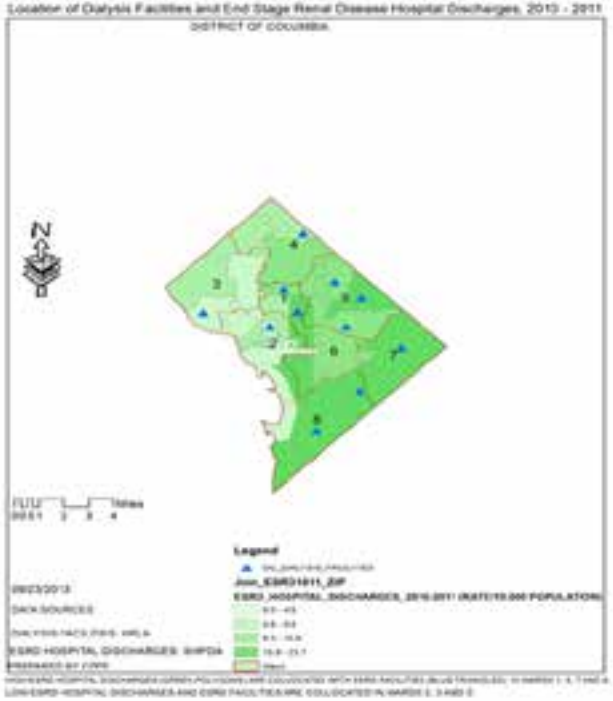


Figure 7: Collocated Dialysis Facilities, ESRD Hospital Discharges and Diabetes, 2010 - 2011

Figure 7 shows high ESRD (Red Dots) and Diabetes (Green Polygons) are collocated in Wards 2, 5, 6, 7 and 8 zip codes.

ESRD Dialysis Facilities (blue triangles), high ESRD hospital discharges and diabetes are collocated in Wards 5, 7 and 8 zip codes (Figure 7).

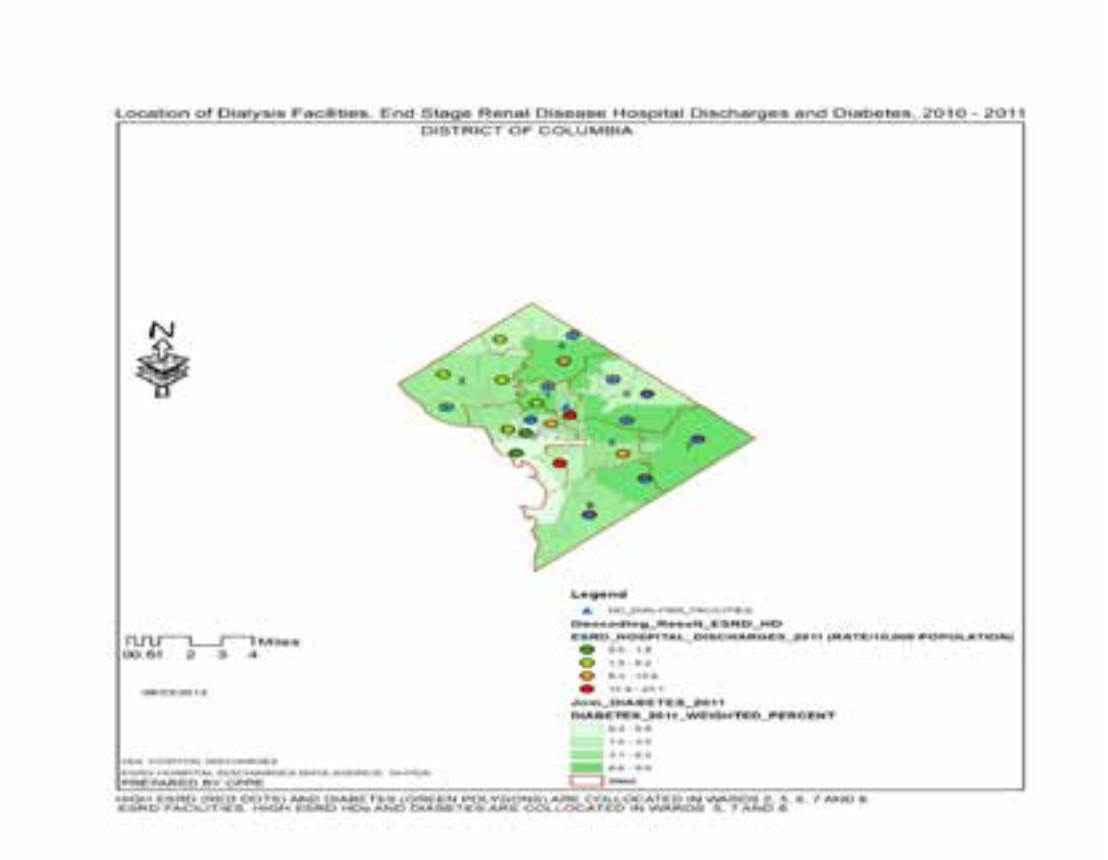
High diabetes and ESRD hospital discharges are collocated in Wards 5, 7 and 8 zip codes (Figure7).

Figure 7 shows collocated high ESRD hospital discharges and diabetes in Wards 5, 7 and 8 zip codes (Figure 7).

More ESRD dialysis facilities are collocated in high ESRD, ESRD hospital discharges and diabetes zip codes (Figure 7).

On the contrary, low number of dialysis facilities are collocated in low ESRD, ESRD hospital discharges and diabetes zip codes (Figure 7).

Figure 7: Collocation of ESRD Dialysis Facilities, ESRD Hospital Discharges and Diabetes, 2010 - 2011



Figures 8 – 9: Hot Spot and Spatial Pattern Analysis of ESRD Deaths and ESRD, 2012

Figures 8 – 9 show optimized cluster analysis of ESRD deaths overlaid on dialysis Treatment Centers.

Zip codes in red are hot spots of ESRD deaths with 99 percent confidence (p </ 0.01) in wards 1, 2, 3, 4, 5 and 6 (Figure 8).

Zip codes in blue are cold spots of ESRD deaths with 99 percent confidence (p </ 0.01) in ward 2 (Figure 8).

Yellow polygons represent “not significant” ESRD deaths (Figure 8).

High ESRD death rates (7.6 – 11.1) shown as green polygons are located in wards 4 and 5 zip codes (Figure 9).

Low ESRD death rates (</ 1.5) shown as light green polygons are located in wards 2, 3, 4, 5 and 6 zip codes (Figure 9).

Figures 8 – 9: Hot Spot and Spatial Pattern Analysis of ESRD Deaths and ESRD, 2012

Figure 8: Hot Spots of ESRD Deaths, 2012

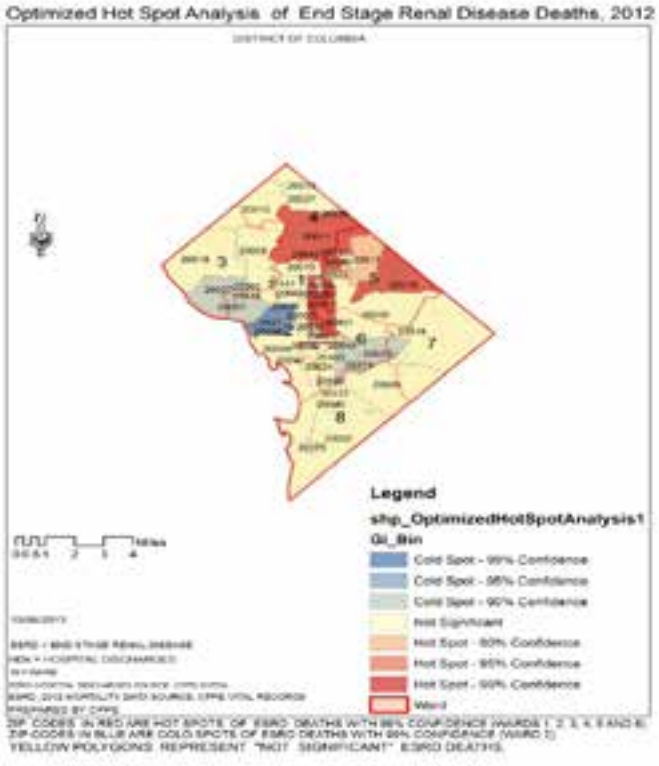


Figure 9: Spatial Patterns of ESRD Deaths, 2012

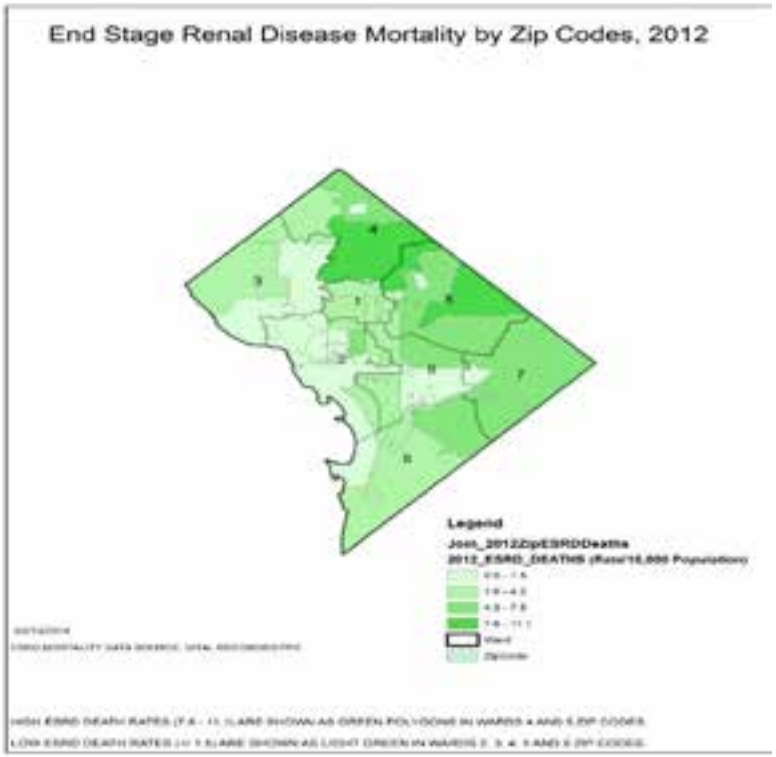


Figure 10: Cigars/Pipe Tobacco Products by Zip Codes and ESRD Hospital Discharges by Zip Codes, 2010-2011

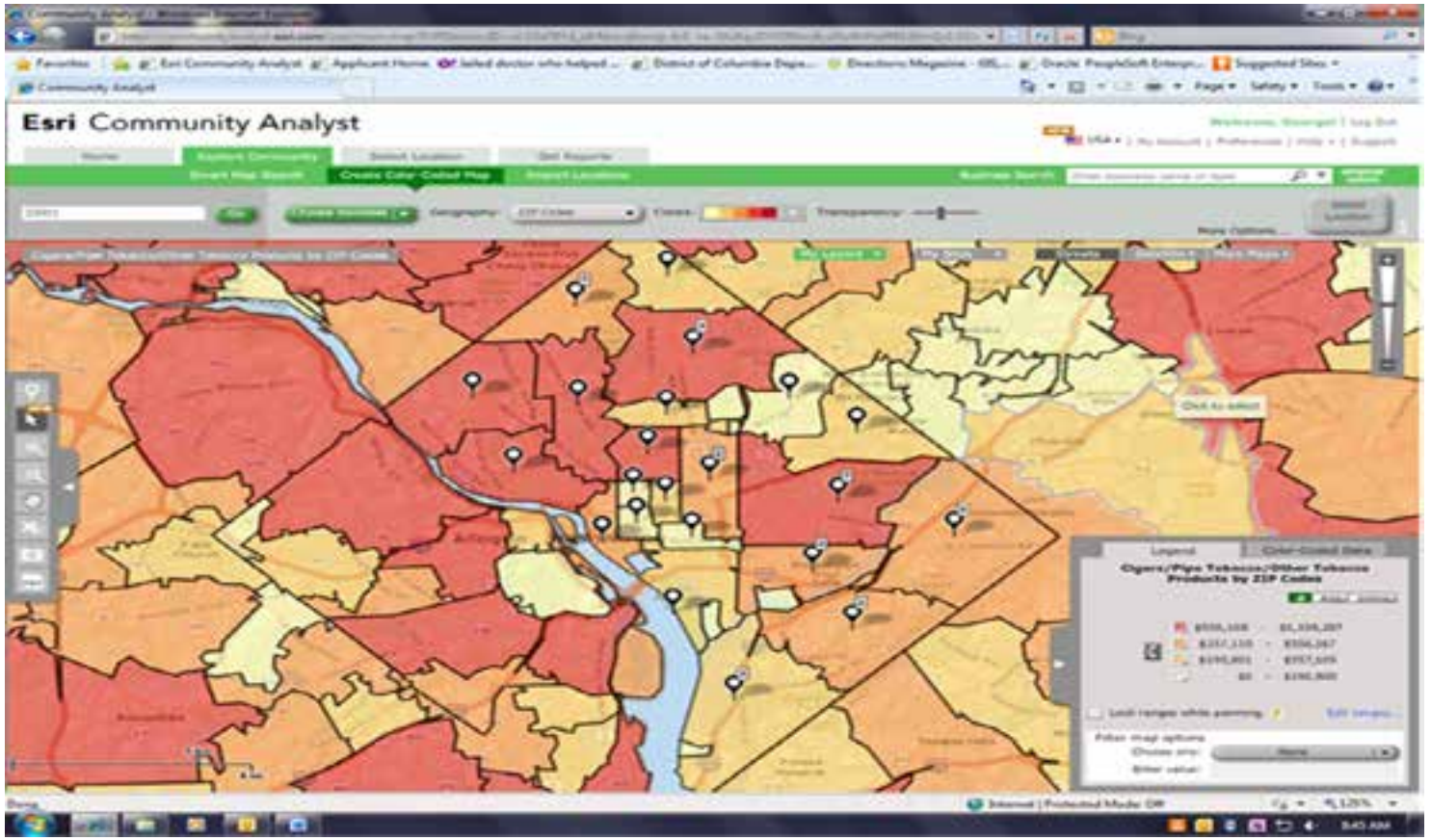
Tobacco sales is being used as a surrogate indicator for smoking (Figure 10).

Figure 10 shows spatial patterns of ESRD hospital discharges (push pins) and tobacco use in which high tobacco expenditures (red polygons) and ESRD are collocated in Wards 1, 2, 3, 4, 5 and 6 zip codes.

Figure 10 shows high tobacco expenditures or use ranging from $57110.00 - $1,108,287.00 (pink – red polygons).

Generally, fewer ESRD hospital discharges are collocated in zip codes with low tobacco expenditures ($0 - $357,109.00/yellow – gold polygons).

Figure 10: Cigars/Pipe Tobacco Products by Zip Codes and ESRD Hospital Discharges by Zip Codes, 2010-2011



Figures 11 – 12: Optimized Hot Spot Analysis of ESRD and Treatment Facilities, 2012

Figure 11 shows ESRD mortality hot spots with 99% Confidence in Wards 1, 2, 4, 5 and 6 zip codes (red polygons).

Figure 11 also shows ESRD hot spots at 95% Confidence in Ward 5 zip codes (light pink polygons).

ESRD and ESRD mortality cold spots with 99% Confidence are shown as blue polygons in Ward 2 zip codes (Figures 11 – 12).

Spatial patterns of ESRD and ESRD mortality hot spots are consistent in Wards 1, 2 and 6 zip codes (Figures 11 – 12).

Collocation of ESRD and ESRD mortality hot spots presents a high public health burden in these zip codes.

Collocation of ESRD and ESRD mortality cold spots in Ward 2 zip codes illustrates the low public health burden in Ward 2 zip codes.

Figures 11 – 12: Optimized Hot Spot Analysis of ESRD and Treatment Facilities, 2010 - 2012

Figure 11: Optimized Hot Spots of ESRD Mortality and Treatment Facilities, 2012

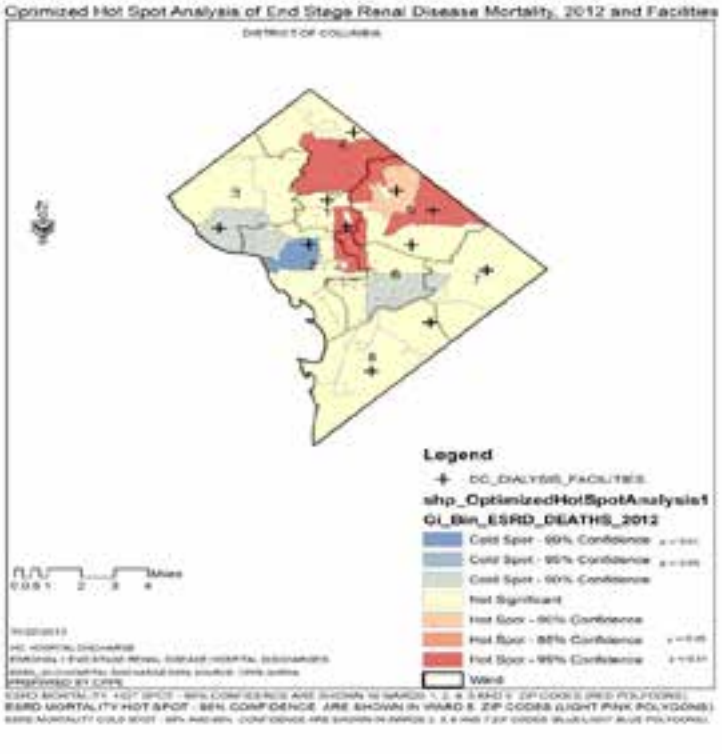
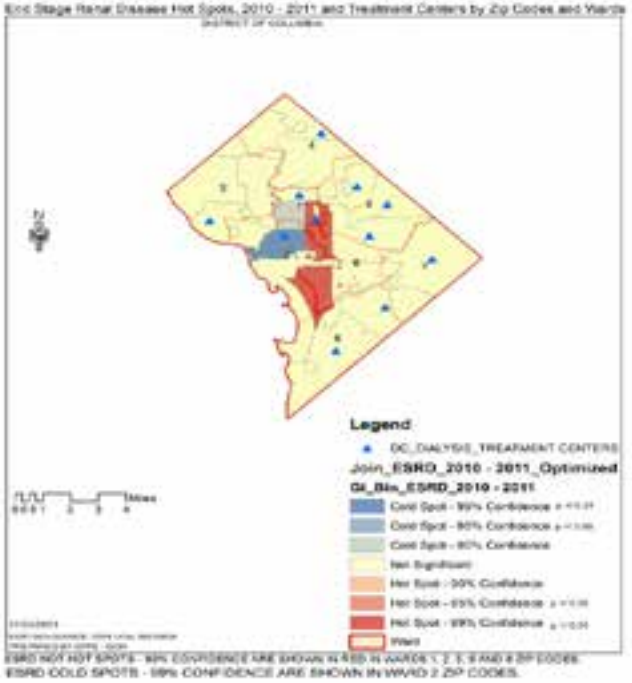


Figure 17: Optimized Hot Spots of ESRD and Treatment Facilities, 2012



Figures 13 – 14: Optimized Hot Spot Analysis of Diabetes, ESRD and ESRD Treatment Centers, 2012

Figure 13 shows diabetes hot spots at 95% Confidence in Wards 1, 2, 3, 4, 5, 6, 7 and 8 zip codes (red polygons).

Figures 13 – 14 show diabetes and ESRD cold spots at 99% Confidence are consistent in Ward 2 zip codes (blue polygons).

Diabetes and ESRD hot spots (99% Confidence) are collocated in wards 1, 2 and 6 zip codes (Figure 14).

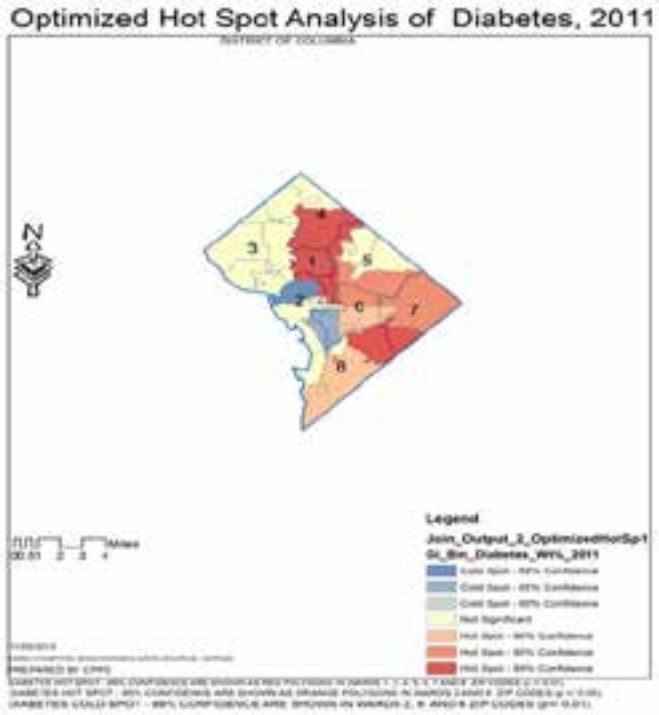
Spatial patterns of diabetes and ESRD hot spots at 95% Confidence are consistent in Ward 6 zip codes (red polygons).

Figures 13 – 14 illustrate spatial disparities in diabetes, ESRD, ESRD hospital discharges and deaths.

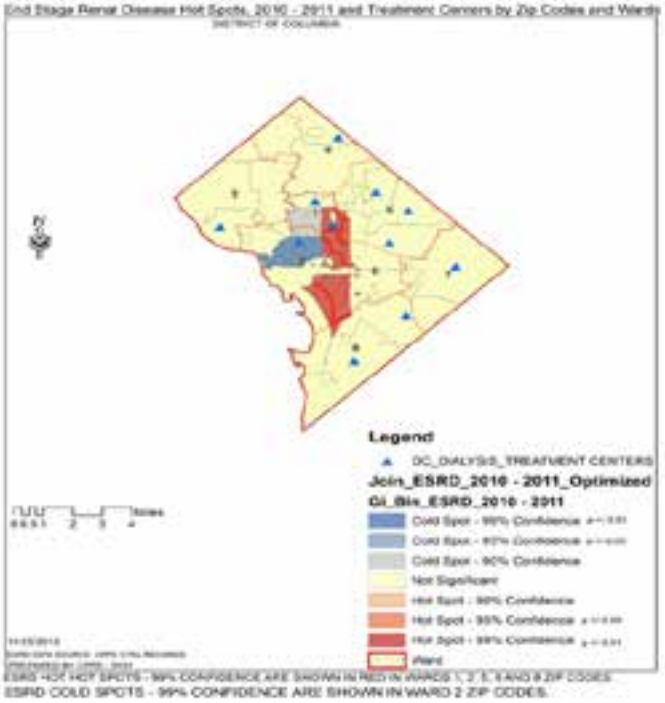
ESRD treatment centers are collocated in both high and low diabetes and ESRD zip codes.

Figures 13 – 14: Hot Spots of Diabetes, ESRD and Dialysis Treatment Centers

Figure 13: Hot Spots of Diabetes, 2011



Figures 14: Hot Spots of ESRD, 2011 and Treatment Centers



Figures 15 – 16: Predictive Modeling of Diabetes, 2012 and ESRD, 2010 - 2011

Figure 15 shows diabetes collocated in shades of pink, light red and red polygons are predicted to have diabetes rates >/ 6.0 - 9.9.

As shown in Figure 15, diabetes collocated in shades of blue, green, olive green, yellow and gold polygons are predicted to have diabetes </ 6.0%.

Figure 16 shows ESRD collocated in shades of gold, pink, light red and red polygons are predicted to have ESRD rates >/ 14.3 – 23.1.

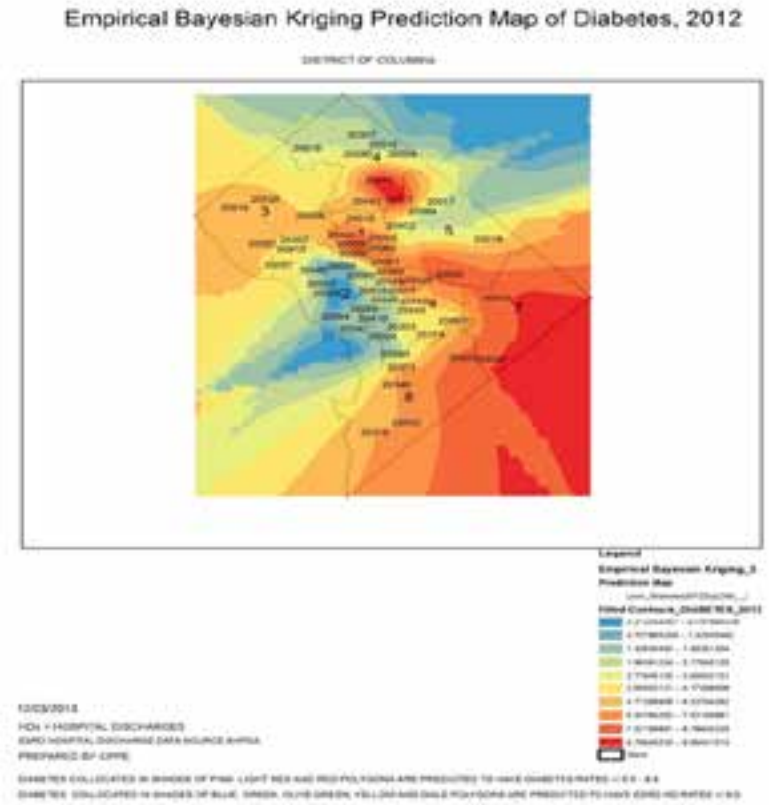
Figure 16 shows ESRD collocated in shades of blue, light blue, sky blue, green, olive green and yellow polygons are predicted to have ESRD rates </ 14.3.

Predictive mapping enables decision makers anticipate future trends with some level of certainty.

Figures 15 – 16: Predictive Modeling of Diabetes, 2012 and ESRD, 2010 - 2011

Figure 16: Predictive Map of ESRD, 2010 - 2011

Figure 15: Predictive Map of Diabetes, 2012



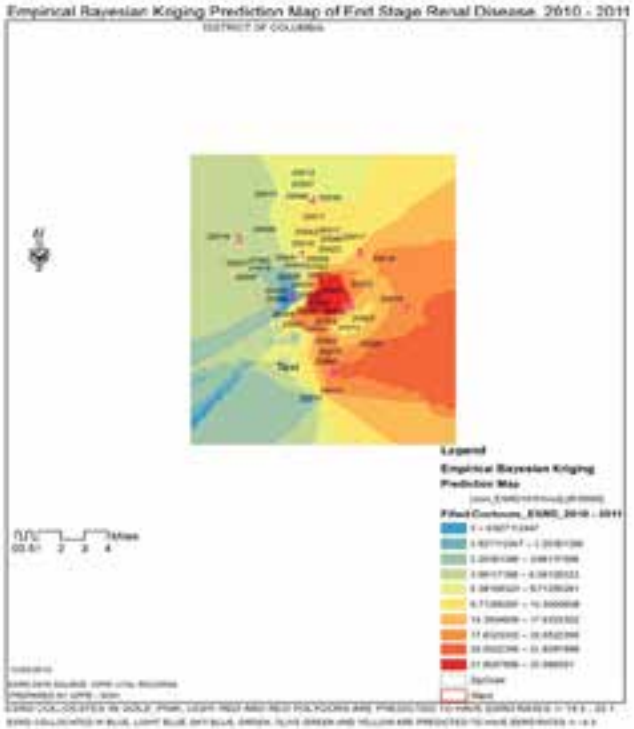


Figure 17: Prediction Standard Error Map of Diabetes and ESRD, 2010 - 2012

Since standard errors for ESRD are consistent with that of diabetes, only ESRD

standard errors are shown.

Only zip code 20019 has standard errors >/ 6.3 (Figure 17).

High errors are concentrated at the edges of the study area, probably due to low sampling (Figure 15).

As shown in Figure 15, zip codes collocated in white polygons have low ESRD errors at 1.2% - 3.3%.

Prediction standard errors provide the level of uncertainty associated with the predictive maps.

Figure 15: Prediction Standard Error Map of Diabetes and ESRD

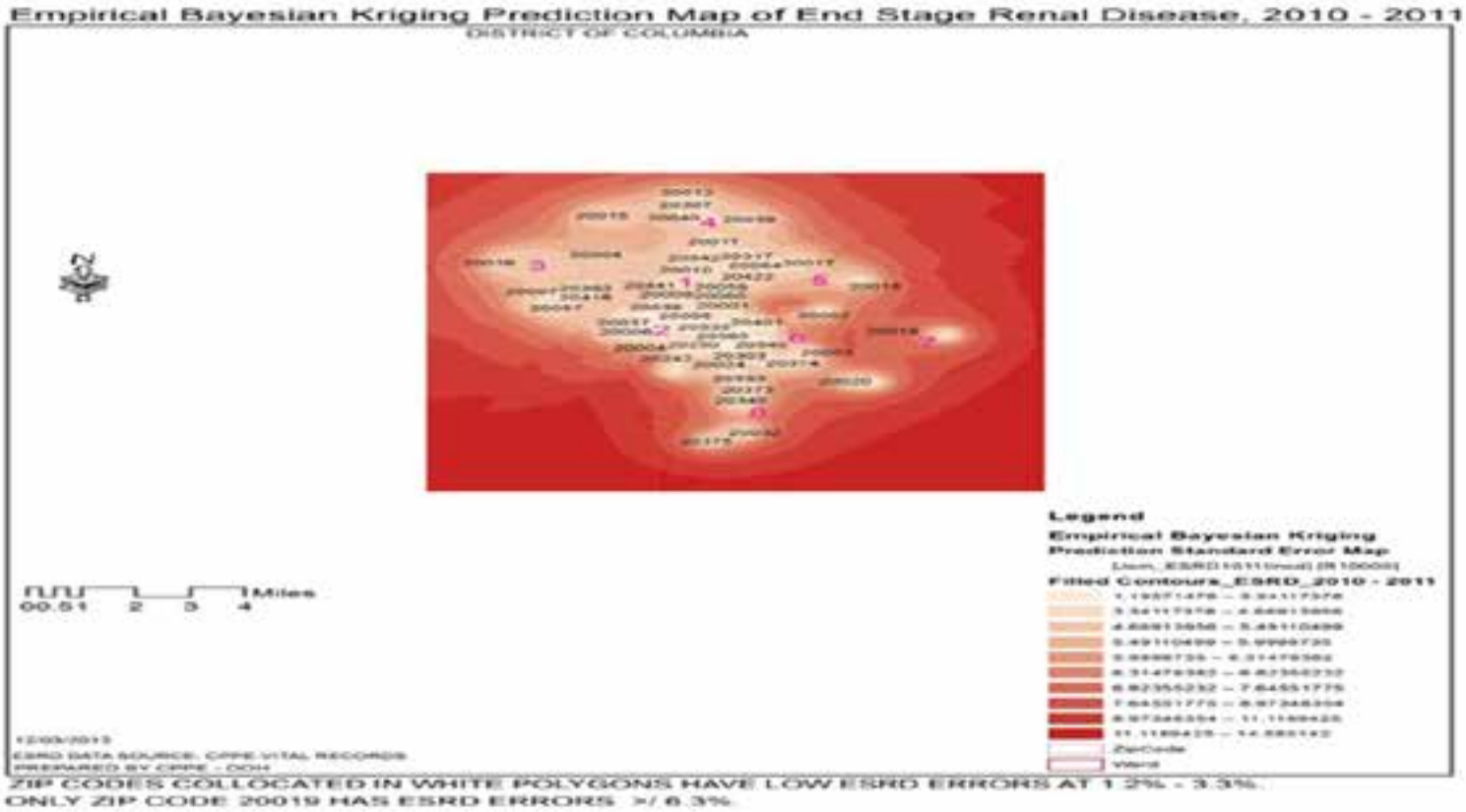


Figure 16: Spatial Autocorrelation Analysis of Renal Disease Hospital Discharges, 2010

Only spatial autocorrelation statistics are shown for ESRD hospital discharges due to their similarity to diabetes, tobacco use, ESRD and lifestage groups.

In Figure 16, the low Moran's I (0.53), reveals the presence of clusters of ESRD hospital discharge rates that are high or low.

Z-score of 19.52 standard deviations falls outside the critical value (-2.58 and +2.58 standard deviations).

Means that at the 0.01 Confidence level, we are 99 percent certain the clustered distribution pattern for ESRD hospital discharges could not be the result of random chance.

That is there is less than one percent likelihood that the cluster patterns could be the result of a random chance.

Figure 16: Spatial Autocorrelation Analysis of Renal Disease Hospital Discharges, 2010

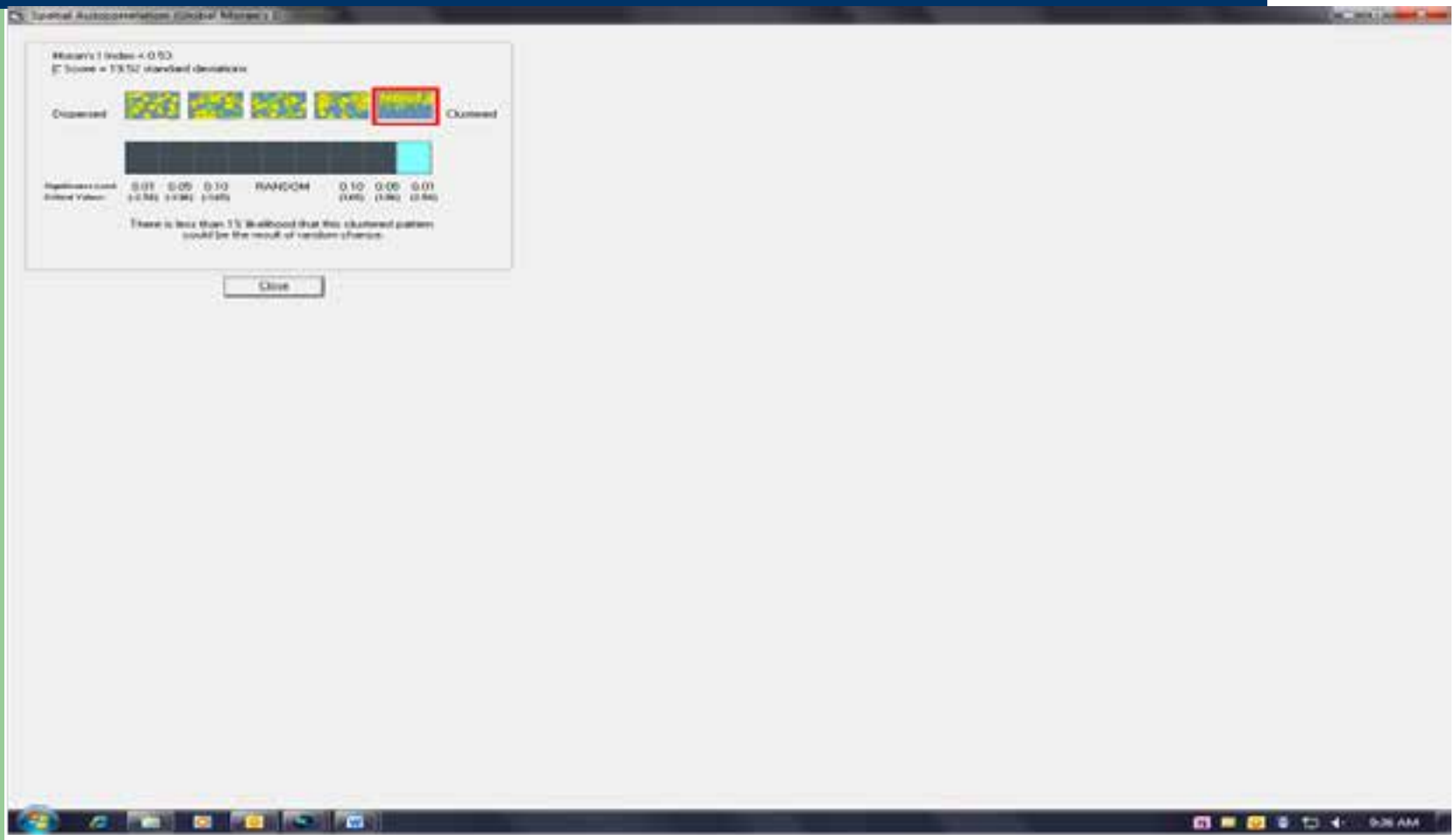


Figure 17: ESRD Deaths, 2012 and Lifestage Groups, 2013

Figure 17 shows spatial patterns of ESRD deaths and lifestage groups.

ESRD deaths greater than or equal to 4.9% are shown in zip codes within Wards 2, 4, 5 and 8.

Zip codes in these Wards are collocated with Young Achievers, Affluent Empty Nests, Conservative Classics, Cautious Couples and Sustaining Families.

Table 2 shows the dominant lifestage groups in the study area.

Lifestage group characteristics can be used to target high ESRD, diabetes and tobacco use intervention strategies (Table 2).

Figure 17: ESRD Deaths, 2012 and Lifestage Groups, 2013

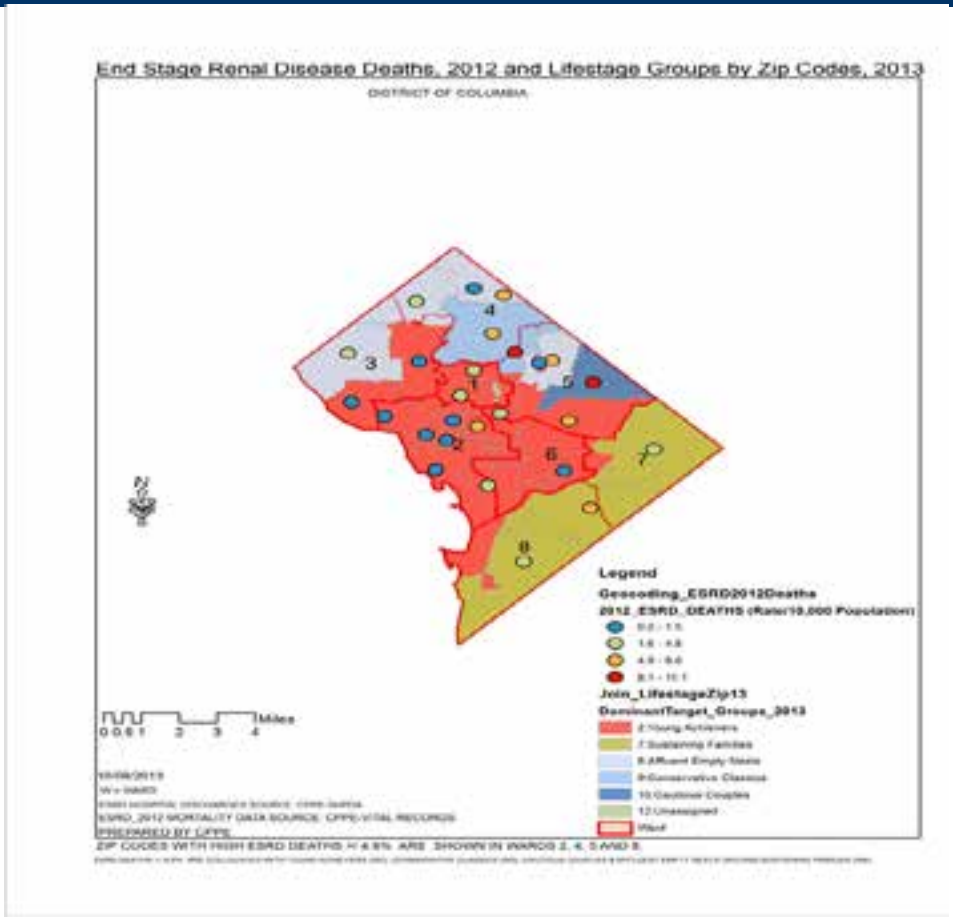


Table 2: Dominant Life Stage Group Characteristics

Lifestage Group	Selected Description	Ethnicity	Ward
Young Achievers	Median HH Income: $91,104, Family Mix - Order from expedia.com - Go water skiing - Read The Economist - Watch Independent Film Channel - Audi A3	White, Asian, Hispanic, Mix	1, 2, 3, 4, 5, 6, 7, 8
Sustaining Families	Median HH Income: $25,761, Mostly w/ Kids - In-home cosmetics purchase - Domestic travel by bus - Read Ebony - Watch BET - Nissan Pathfinder	White, Black, Hispanic, Mix	1, 6, 7, 8,
Affluent Families	Median HH Income: $121,186, HH w/o Kids - Shop at Saks Fifth Ave. - Belong to a country club - Read Conde Nast Traveler - Watch Golf Channel - Mercedes SL Class	White, Asian, Mix	1, 2, 3, 4, 5, 6 7
Conservative Classics	Median HH Income: $59,750, Mostly w/o Kids - Shop at Costco - Buy classical music - Read Harper's Bazaar - Watch BBC America - Lexus LX	White, Black, Asian, Hispanic	2, 3, 4, 5, 7
Cautious Couples	Median HH Income: $43,049, Mostly w/o Kids - Shop at Macy's - Domestic travel by railroad - Read The New Yorker - Watch The View - Chrysler PT Cruiser	White, Black, Asian, Hispanic	3, 5, 6, 7

I: Discussion

Zip codes 20001, 20020, 20018, 20019, 20024 and 20032, located in Wards 1, 2, 4, 5, 6, 7 and 8, show a high burden of ESRD hospital discharges.

Consistent with other findings that the District has the highest rates of ESRD in the nation[3].

Collocation of high ESRD deaths and hospital discharges in Wards 2, 4, 5 and 8 zip codes illustrates the high public health burden in these zip codes.

ESRD deaths greater than or equal to 7.6 percent are high in zip codes 20012 (Ward 4) and 20018 (Ward 5).

ESRD hospital discharges are collocated with most of the 65-plus age group.

Consistent with risk factors for chronic kidney disease and ESRD among others, including older age[2, 3].

Spatial overlays showed homes with high tobacco products are generally collocated with high ESRD hospital discharges.

II: Discussion

High diabetes are collocated with high ESRD hospital discharges in Wards 1, 2, 4, 6, 7 and 8 zip codes .

Suggests a high public health burden for ESRD hospital discharges and diabetes for zip codes in Wards 1, 2, 4, 6, 7 and 8.

Spatial autocorrelation results show the similarity between spatial patterns of ESRD hospital discharges and deaths, diabetes, and tobacco expenditures are not due simply to chance ($p </ 0.01$).

Conclusions

High ESRD, ESRD hospital discharges, the 65-plus age groups, tobacco use and diabetes are collocated in certain zip codes.

Tobacco expenditures are generally collocated with ESRD hospital discharges in all ward zip codes, except ward 3 zip codes.

Generally, proximity of ESRD treatment centers to ESRD deaths and hospital discharges does not seem to affect the prevalence of ESRD, ESRD deaths and hospitalization in the affected community.

Clearly, collocation of high ESRD, ESRD hospital discharges and deaths, diabetes, tobacco use and a vulnerable population group illustrates the high public health burden of ESRD.

Conclusions

Zip codes 20012 (Ward 4) and 20018 (Ward 5) have ESRD deaths greater than or equal to 7.6 percent.

Identified zip codes 20012 (Ward 4) and 20018 as having high ESRD deaths (>/ 7.6%).

Disparities in diabetes, ESRD, ESRD hospital discharge and death rates are shown across all zip codes.

Kriging, optimized hot spot and cluster analysis with rendering can be used to anticipate and recognize the significance of geographic variation in phenomena.

Quantifying spatial patterns provides a level of certainty that can enhance evidence-based decision making.

Collocation of ESRD, ESRD hospital discharges and deaths, and tobacco use and diabetes suggests the need for programmatic collaboration with ESRD dialysis program and treatment facilities.

Limitations

Alcohol and exercise data were not available at the zip code scale and not included in this study.

Ward data are at a much larger scale than zip codes and cannot be subjected to spatial statistical analysis due to the number of wards being less than ten.

ESRI Community Analyst does not have the capability to import categorized values of imported variables and only represents such imported variables as push pins.

Categorizing ESRD hospital discharges would show where high and low rates of ESRD hospital discharges and tobacco sales are collocated.

Lessons Learned

Both high and low diabetes and ESRD are collocated with ESRD treatment centers.

Collocation of fewer dialysis facilities with ESRD hospital discharge cold spots highlights the issue of treatment center effectiveness.

Except in ward 2 zip codes, proximity to and number of dialysis facilities does not impact the prevalence of ESRD.

Collocation of ESRD, diabetes and tobacco use creates the need for collaboration across programs.

ESRD hospital discharges can be used as a surrogate indicator for ESRD.

Zip codes 20001, 20002, 20003, 20010 20011 20017, 20018, 20019, 20020, 20024 and 20032 show that for every group of 10,000 people, there is “double digit” ESRD hospital discharges per 10,000 people.

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