PEER REVIEW HISTORY

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ARTICLE DETAILS

TITLE (PROVISIONAL)	Associations between community well-being and hospitalization rates: results from a cross-sectional study within six US states
AUTHORS	Roy, Brita; Riley, Carley; Herrin, Jeph; Spatz, Erica; Hamar, Brent; Kell, Kenneth; Rula, Elizabeth; Krumholz, Harlan

VERSION 1 – REVIEW

REVIEWER	Thomas Kottke HealthPartners, HealthPartners Institute and the University of Minnesota School of Medicine United States
REVIEW RETURNED	15-Mar-2019

GENERAL COMMENTS	Review of: Associations between community well-being and hospitalization rates: results from a cross-sectional study within six US states Roy, B et al. Brief synopsis: The authors used all-payers data bases in 6 states and the Gallup-Sharecare Well-being Index (WBI) to test the association between well-being and hospitalization rates in communities. They found that the zip codes with the highest level of well-being had 223 fewer hospitalizations per 100,000 residents than zip codes with the lowest level of well-being. In the fully-adjusted model, a one standard deviation increase in the WBI was associated with 5 fewer admissions/100,000 residents (95% CI: 4.0-5.8; p<0.001). The authors conclude that their findings lay the groundwork for more formal testing to assess whether improving community well-being may also be a target for reducing unnecessary hospitalizations. The difference in hospitalizations across 2 standard deviations of WBI would be 10 fewer admissions/100,000 residents. Frankly, this is a trivial difference. The following text is from the H-CUP web site: “Patients residing in the lowest income areas had the highest rate of stays (122.7 vs. 82.5 stays per 1,000 population in the highest income areas)” https://www.hcup-us.ahrq.gov/reports/statbriefs/sb246-Geographic-Variation-Hospital-Stays.jsp . Of course, these rates are not age adjusted, but when these rates are converted to admissions per 100,000 population, they are 12,270/100,000 and 8,250/100,000. This makes the crude range of hospitalization/rate attributable to difference in WBI only about 2% of the total hospitalization rate. By comparison, Reid KW et al. (reference 3) found that homelessness was associated with a

	hospitalization rate that was approximately twice as high as the rate for all income levels. The WBI is an index of subjective well-being. Measures of objective well-being also exist and are based on the physical and social environment—housing, wealth, education, crime rates, health statistics, etc. While it is my opinion that the subjective well-being of entire communities ought to be addressed and the health needs of the poor ought to be addressed, the analysis of Roy et al. show that the association between community subjective well-being and hospitalization rates is very small—one might say, "trivial." Arguing that increasing community well-being will reduce the need for hospitalization is likely to lead to disappointment. If the goal is to reduce hospitalization rates, the components that define objective well-being (and I believe that further analysis of this data set will show that poverty will emerge as the factor most strongly associated with hospitalization rates) need to be addressed. Other observations: It appears to me that the figure displays the hospitalization rates without adjustment. This being the sole figure, it might lead the reader to believe that it represents the difference in hospitalization rates attributable to well-being when, in fact, the range is due to confounding by demographic variables. I think that the paper would benefit greatly from a table that shows the difference in well-being score and hospitalization rates by age, race and income. This would show that well-being has a relatively trivial impact on hospitalization rates relative to factors like poverty. I would be surprised if poverty were not the factor most strongly associated with community well-being. Also, since the authors present the health services data by well-being quintile in table 1, it would be helpful to see the adjusted hospitalization rates by well-being quintile. The authors have extensively cited the literature on the social determinants of well-being. Of note: I have an ongoing concern that Gallup-Sharecare does not report their response rates to their attempts to interview. This is true for most current surveys. This leaves the user without information about potential non-response bias. However, this is not my major concern with the manuscript.

REVIEWER	Jie Chen University of Maryland, School of Public Health
REVIEW RETURNED	22-Mar-2019

GENERAL COMMENTS	The study aims to examine the association of community well-being and the hospitalization rates at the zip-code level. Literature of community impact on health outcomes is extensive. Using the WBI is a significant part of this analysis. My main question is whether the WBI can be used at the zip-code level (i.e. whether the WBI is zip-codes representative). I also have a few other

	questions on the method and data to help me understand the approach/results better. 1. It is not clear to me whether the Gallup-Sharecare Well-being Index (WBI) is zip-codes representative? For example, if there were only a few sampling points in one zip code, then the average WBI of these few points might not represent the entire zip code without using the appropriate sampling weight. It is not clear whether the survey weights were used in the analysis. This is a critical issue of this study. 2. The linkage between the WBI and the HCUP data needs to be clarified. The WBI is developed from a survey. Were all the zip codes matched? How many zip-codes had missing values of the WBI? 3. Components of the WBI is quite interesting, especially the life evaluation, emotional health, etc. The current results, however, did not reflect the association of these components. It will be interesting to study and compare the association of component of access vs. emotional health, for example. 4. Overall, I think the study design should be written in a more coherent way. What is the age range of the study population? All age groups? The WBI is developed for adults aged 18+ though. Some variables, such as healthcare intensity variables, are not defined. A summary statistics of the outcome variables and all covariates will be helpful to understand the analysis. 5. Results with a full list of covariates will be needed to understand the robustness of the analysis. It will be important to see the association between other covariates and the outcomes. I am also curious about the model multi-collinearity issue. For example, the WBI may be correlated with other demographic or SES characteristics, and maybe state indicator as well. In addition, the model fit and other statistics of the model will be helpful to understand the estimation. 6. The outcome measures should be explained in more details. Why not using the preventable hospitalization rates, developed by the AHRQ, rather than hospitalization rates? What are the distributions of the outcome variables? It is not clear whether the linear regression is the right choice. 7. Finally, the data sets were obtained from the 2010 HCUP. The HCUP has recent 2017 data, and the WBI is also available. Is it possible to apply the analysis on more recent data to reflect ongoing major policy changes (e.g. the ACA is 2014, Medicaid expansion, macro economy, etc.)? This will significantly improve the policy implications.

VERSION 1 – AUTHOR RESPONSE

Reviewer #1:

Brief synopsis: The authors used all-payers data bases in 6 states and the Gallup-Sharecare Well-being Index (WBI) to test the association between well-being and hospitalization rates in communities. They found that the zip codes with the highest level of well-being had 223 fewer hospitalizations per 100,000 residents than zip codes with the lowest level of well-being. In the fully-adjusted model, a one standard deviation increase in the WBI was associated with 5 fewer admissions/100,000 residents (95% CI: 4.0-5.8; p<0.001). The authors conclude that their

findings lay the groundwork for more formal testing to assess whether improving community well-being may also be a target for reducing unnecessary hospitalizations.

The difference in hospitalizations across 2 standard deviations of WBI would be 10 fewer admissions/100,000 residents. Frankly, this is a trivial difference. The following text is from the H-CUP web site: "Patients residing in the lowest income areas had the highest rate of stays (122.7 vs. 82.5 stays per 1,000 population in the highest income areas)" https://nam05.safelinks.protection.outlook.com/?url=https%3A%2F%2Fwww.hcup-us.ahrq.gov%2Freports%2Fstatbriefs%2Fsb246-Geographic-Variation-Hospital-Stays.jsp&data=02%7C01%7Cbrita.roy%40yale.edu%7Ca363b69cf74d4c47887808d6c44f54c1%7Cdd8cbebb21394df8b4114e3e87abeb5c%7C0%7C0%7C636912242356921097&sdata=HBbu4LeSqdzCdBRP7a2dyXn02fnDCAGU4LbQWhdjqHI%3D&reserved=0.

Response: We agree that the magnitude of the difference in hospitalizations associated with an increase in two standard deviations of the WBI is small, especially after adjusting for many other factors, including income. We included race, ethnicity, income, and healthcare system capacity as covariates in our models to explore whether an additional independent association between hospitalizations and community well-being exists above and beyond the effects of those socioeconomic factors known to be strongly associated with hospitalization rates. Though the effect is small in absolute terms, it is important to remember that this is a community effect. Moreover, the additional effect of well-being is important because components of well-being can be improved by community members, unlike income. As such, acknowledging the incremental benefit of well-being on a high-value healthcare outcome such as hospitalizations may be a mechanism to leverage partnerships among health systems and community stakeholders to improve well-being and could plausibly reduce unnecessary hospitalization rates. We have modified the text in the Discussion section to support this in lines 281-284 and lines 306-330:

> *Community well-being is modifiable and supporting programs and policies to foster community well-being should be a society's end goal.[24-26] Our results suggest that promoting community well-being may have an additional benefit of curbing unnecessary hospitalization rates, as well as supporting other beneficial population health outcomes, including longer life expectancy and lower rates of preterm birth...[27-29]*
>
> *We report cross-sectional associations at the zip code level, and thus, we are unable to make causal inferences. However, it suggests that the efforts communities and policymakers are engaged in globally to improve community well-being may also have a modest effect on reducing hospitalization rates. Our team recently reported that there are modifiable community characteristics, such as education levels, diversity, rates of preventive care, and rates of active commuting that are associated with higher well-being of community residents.30 In addition, a prospective study in which municipal officials approved and permitted community-member driven environmental changes (e.g., street murals, public benches, and planter boxes, in public spaces) also resulted in improved well-being.31 32 Residents within a two-block radius of the transformed sites were systematically sampled and reported improvements in mental health, increased sense of community, and an overall expansion of social capital. More comprehensive, longitudinal studies, such as the ongoing Well-London Study,24 25 are needed to assess whether systemic community-based interventions influence well-being, and if they result in better population health outcomes, as hypothesized.*
>
> *In general, these community-based interventions that improve well-being, such as improving housing conditions, safety, and education, are linked to lower rates of hospitalization. As such, promoting community well-being as a target outcome is likely to also result in reducing unnecessary hospitalizations as community conditions are improved. However, our study suggests there is a small but important additional reduction in hospitalizations attributable to higher community well-being itself.*

Of course, these rates are not age adjusted, but when these rates are converted to admissions per 100,000 population, they are 12,270/100,000 and 8,250/100,000. This makes the crude range of hospitalization/rate attributable to difference in WBI only about 2% of the total hospitalization rate. By comparison, Reid KW et al. (reference 3) found that homelessness was

associated with a hospitalization rate that was approximately twice as high as the rate for all income levels.

Response: With respect to the 2% of the total hospitalization rate, we agree that the percentage attributable to WBI is low compared to factors like income or homelessness, but the magnitude is similar to that of other community-level psychosocial factors like social cohesion, social capital, and collective efficacy (reference #37-39). Though the effect size is small, because it this a community effect, the extrapolated absolute number of hospitalizations is quite large across the United States. Using a conservative estimate and assuming the two percent lower hospitalization rate only affects ambulatory sensitive conditions, applying this rate to 1582 preventable hospitalizations per 100k (Dartmouth Atlas, 2012), this would equate to approximately 100,000 fewer hospitalizations per year. The average hospitalization in the US costs roughly $10,000, and thus there would be an associated savings of near $1B in healthcare costs. We have added a summary of this calculation to the Discussion section (lines 281-284): "If all zip codes in the US had well-being scores in the highest quintile, based on our findings, we would expect approximately 100,000 fewer hospitalizations yearly, saving nearly $1 billion in healthcare costs."

It is also important to note that the Reid paper was reporting risk in individuals, with 23.6% of those who were homeless having had a hospitalization in the past year compared with about 8% of those in the general population. The fact that they are looking backward could also mean that the hospitalization caused the homelessness – and so the estimates in that paper are not germane for our paper.

The WBI is an index of subjective well-being. Measures of objective well-being also exist and are based on the physical and social environment—housing, wealth, education, crime rates, health statistics, etc.

While it is my opinion that the subjective well-being of entire communities ought to be addressed and the health needs of the poor ought to be addressed, the analysis of Roy et al. show that the association between community subjective well-being and hospitalization rates is very small—one might say, "trivial." Arguing that increasing community well-being will reduce the need for hospitalization is likely to lead to disappointment. If the goal is to reduce hospitalization rates, the components that define objective well-being (and I believe that further analysis of this data set will show that poverty will emerge as the factor most strongly associated with hospitalization rates) need to be addressed.

Response: We appreciate this comment and we agree with it. We have reframed the discussion and conclusions to support the idea that improving community well-being should be the end goal, and as a byproduct, we may also achieve better health outcomes, including reduction in unnecessary hospitalizations and other population health outcomes (lines 273-282).

In addition, while the number of fewer hospitalizations after controlling for sociodemographics is small, we feel it is important. As above, because it is a community effect, if the well-being of the nation improved by two standard deviations, it is possible that there would be an associated 100,000 fewer hospitalizations.

Other observations:

It appears to me that the figure displays the hospitalization rates without adjustment. This being the sole figure, it might lead the reader to believe that it represents the difference in hospitalization rates attributable to well-being when, in fact, the range is due to confounding by demographic variables.

Response: We appreciate the reviewer's comment. However, we do feel that the clear, graded relationship between community well-being and hospitalization rates is meaningful for readers to visualize. We have modified the figure caption to be clear that it is only adjusted for age. We do not state that the patterns are attributable to well-being.

I think that the paper would benefit greatly from a table that shows the difference in well-being score and hospitalization rates by age, race and income. This would show that well-being has

a relatively trivial impact on hospitalization rates relative to factors like poverty. I would be surprised if poverty were not the factor most strongly associated with community well-being.

Response: Showing the difference in hospitalization rates by age, race, and income is beyond the scope of this paper, and has been reported elsewhere.[Gornick, et al., NEJM 1996; Pappas, et al., AJPH 1997] However, we have modified Table 1 to include age, race, and income as additional rows and show differences in these variables across well-being quintiles. This allows readers to see that these sociodemographic variables are all associated with community well-being, and this is followed by Table 2, Model 2, as well as a new Table 3, which reflect how much of the association between well-being and hospitalization is explained by those sociodemographic factors. We have summarized the differences in these sociodemographic factors across quintiles of well-being in the Results section (lines 234-237): "Zip codes with higher WBI tended to have fewer adults over age 65, though there was no difference in any other age groups. Zip codes with higher WBI also had higher median household income, but there was no difference in percent white residents."

Also, since the authors present the health services data by well-being quintile in table 1, it would be helpful to see the adjusted hospitalization rates by well-being quintile.

Response: We thank the reviewer for this suggestion.We have added a table in the Appendix that shows adjusted hospitalization rates by well-being quintile and have summarized these results in the text (Lines 245-248): "After adjustment for age, sex, race, income, and healthcare intensity variables, zip codes in the highest quintile of well-being had 9% fewer hospitalizations than zip codes in the lowest quintile of well-being (absolute difference of 12 per 100k residents)."

The authors have extensively cited the literature on the social determinants of well-being.

Response: Thanks for this compliment.

Of note: I have an ongoing concern that Gallup-Sharecare does not report their response rates to their attempts to interview. This is true for most current surveys. This leaves the user without information about potential non-response bias. However, this is not my major concern with the manuscript.

Response: We appreciate this concern. We do not have access to data on response rates but do know that Gallup weights responses to address this issue of non-response bias.

Reviewer #2:

The study aims to examine the association of community well-being and the hospitalization rates at the zip-code level. Literature of community impact on health outcomes is extensive. Using the WBI is a significant part of this analysis. My main question is whether the WBI can be used at the zip-code level (i.e. whether the WBI is zip-codes representative). I also have a few other questions on the method and data to help me understand the approach/results better.

It is not clear to me whether the Gallup-Sharecare Well-being Index (WBI) is zip-codes representative? For example, if there were only a few sampling points in one zip code, then the average WBI of these few points might not represent the entire zip code without using the appropriate sampling weight. It is not clear whether the survey weights were used in the analysis. This is a critical issue of this study.

Response: Per guidance from Gallup, we excluded zip codes with less than 10 WBI participants. Though Gallup routinely weights survey responses when making inferences about specific regions (or the entire U.S.), it is not necessary when looking at associations as we have here. Because we did not make inferences about the well-being of any particular zip code, but rather assessed relationships between groups (quintiles) of approximately 300 zip codes, the omission of sampling weights does not bias the findings. It is true that the magnitudes of associations may differ with the incorporation of weights, but weights do not exist for our quintiles and their construction is a time intensive process involving iterative evaluation.

The linkage between the WBI and the HCUP data needs to be clarified. The WBI is developed from a survey. Were all the zip codes matched? How many zip-codes had missing values of the WBI?

Response: We had hospitalization data from residents of 25,443 zip codes from the six states for which we had HCUP data. Of these, 20,301 were excluded because their zip code of residence was out of state. An additional 3606 zip codes were not matched because they had fewer than 10 WBI participants. Finally, 49 zip codes were excluded because they had incomplete WBI data (primarily the work environment index, as this was only completed by participants that were currently employed).

Components of the WBI is quite interesting, especially the life evaluation, emotional health, etc. The current results, however, did not reflect the association of these components. It will be interesting to study and compare the association of component of access vs. emotional health, for example.

Response: We appreciate the reviewer's interest in the WBI domain analyses. We did assess the association between each well-being domain and hospitalizations in adjusted and unadjusted models. We have expanded the summary of the results from these models in the final paragraph of the Results section (Lines 265-273): "In general, similar patterns were seen for each of the well-being domains. All domains of well-being were inversely associated with all-cause hospitalizations in unadjusted and adjusted models. The strongest inverse relationships with all-cause hospital admissions were noted with a 1SD increase in the basic access (14.7 fewer admissions/100k; p<0.001), physical health (6.6 fewer admissions/100k; p<0.001), and emotional health (6.6 fewer admissions/100k; p<0.001) domains in unadjusted models. In fully adjusted models, all-cause hospitalizations were most strongly associated with the basic access (8.3 fewer admissions/100k; p<0.001), physical health (4.9 fewer admissions/100k; p<0.001), and emotional health (4.6 fewer admissions/100k; p<0.001) domains." Our team plans to investigate the components of basic access and emotional health and their associations with population health outcomes in future studies.

Overall, I think the study design should be written in a more coherent way. What is the age range of the study population? All age groups? The WBI is developed for adults aged 18+ though. Some variables, such as healthcare intensity variables, are not defined. A summary statistics of the outcome variables and all covariates will be helpful to understand the analysis.

Response: We clarified the description of the sample. On line 138, we now state that Gallup administers the survey to a "random sample of 500 to 1000 adults in the US daily." In addition, we have added, "included data on all adult and pediatric hospitalizations" on line 123. We have also added definitions of hospital beds, PCP density, and hospital density (lines 194-201). Finally, we modified Table 1, as noted above, such that it now includes summary statistics of all outcomes and covariates across well-being quintiles.

Results with a full list of covariates will be needed to understand the robustness of the analysis. It will be important to see the association between other covariates and the outcomes. I am also curious about the model multi-collinearity issue. For example, the WBI may be correlated with other demographic or SES characteristics, and maybe state indicator as well. In addition, the model fit and other statistics of the model will be helpful to understand the estimation.

Response: Thank you for raising the collinearity issue. We used the method of Belsey, Kuh and Welsch (1980) to assess collinearity and using their criteria excluded one of the age group factors, 65-84, from the models. We have now described this in the Methods (Lines 221-223):

> *Methods: "*We used the method of Belsey, Kuh and Welsh to assess the covariates for collinearity; using their criteria we excluded the proportion of respondents between 65 and 84 years of age from the models."

Given the large number of models reported (there are 12 for WBI and 60 more for the domains), it is impractical to report the full model results for each. However, we have added a new Table 3 which has the fully adjusted model results for WBI for the 4 hospitalization rate outcomes.

In order to provide some information about model fit, we have now added to the Results the R^2 values for the fully adjusted WBI models (Lines 261-263):

> "The R^2 values for the fully adjusted WBI model ranged from 0.13 for cancer admissions to 0.43 for CVD admissions; the model for all admissions had an R^2= 0.38"

The outcome measures should be explained in more details. Why not using the preventable hospitalization rates, developed by the AHRQ, rather than hospitalization rates? What are the distributions of the outcome variables? It is not clear whether the linear regression is the right choice.

Response: As a first step and with the data we had available, we chose to focus on all-cause hospitalizations. We did perform sub-analyses with cardiovascular, respiratory, and cancer-related hospitalizations as potentially preventable hospitalizations. However, the full scope of preventable hospitalization rates per AHRQ was outside the scope of this study. We agree that this would be a good follow-up study. Regarding the distributions of the rates, all 4 were distributed symmetrically and approximately normal, indicating that linear regression was an appropriate model.

Finally, the data sets were obtained from the 2010 HCUP. The HCUP has recent 2017 data, and the WBI is also available. Is it possible to apply the analysis on more recent data to reflect ongoing major policy changes (e.g. the ACA is 2014, Medicaid expansion, macro economy, etc.)? This will significantly improve the policy implications.

Response: We appreciate this suggestion. At the time we were performing the study, we used the most recent data for which we had access. However, now that this initial study is complete, we will consider performing a follow-up study that includes post-ACA data and assess how results compare to the pre-ACA time period.

VERSION 2 – REVIEW

REVIEWER	Thomas Erling Kottke HealthPartners Institute USA
REVIEW RETURNED	08-Jun-2019

GENERAL COMMENTS	Review of Associations between community well-being and hospitalization rates: results from a cross-sectional study within six US states Journal: BMJ Open Manuscript ID bmjopen-2019-030017.R1 The authors have responded to most of my concerns. There is no question in my mind that every valid argument should be used to promote the well-being of individuals and populations and that the evidence is strong that modifiable promoters of well-being do exist. However, I also believe that it Is unwise to overstate the case for associations. To do so sets the stage for the need to apologize and retract. None of us who are promoting well-being want that to be the case. The following are suggestions that the authors may wish to consider.

	Line 56: I'd leave this clause out of the conclusion: "Improving community well-being should be society's end goal, and" Line 299: Even though you mention safety in line 313, don't you think that assuring adequate income and increasing public safety ought to be called out as factors associated with better well-being? In your table 1, household income had the highest gradient with well-being. Line 339-441: I suggest deleting this sentence or reword it as, "Though it remains to be tested, these results suggest that policies that promote community well-being may also reduce hospitalization rates." As currently written, it is too complex.

VERSION 2 – AUTHOR RESPONSE

Reviewer #1:

The authors have responded to most of my concerns. There is no question in my mind that every valid argument should be used to promote the well-being of individuals and populations and that the evidence is strong that modifiable promoters of well-being do exist. However, I also believe that it Is unwise to overstate the case for associations. To do so sets the stage for the need to apologize and retract. None of us who are promoting well-being want that to be the case..

Response: Thank you. We worked hard to implement changes based on your prior suggestions. We agree that we do not want to overstate the case for associations with community well-being and we appreciate your additional suggestions to modify our language to prevent that.

Line 56: I'd leave this clause out of the conclusion: "Improving community well-being should be society's end goal, and"

Response: We have removed the clause, "Improving community well-being should be society's end goal." The final sentence of the conclusion of the abstract now reads: "In addition to health and quality of life benefits, higher community well-being may also result in fewer in unnecessary hospitalizations." (Lines 56-57)

Line 299: Even though you mention safety in line 313, don't you think that assuring adequate income and increasing public safety ought to be called out as factors associated with better well-being? In your table 1, household income had the highest gradient with well-being.

Response: The sentence in lines 303-306 refers to results from another paper that identified independent associations of community factors with residents' well-being. While income was one of the twelve factors independently associated with well-being, safety was not. As such, we have included adequate income in line 304, and we include both income and safety among community based interventions that are generally associated with lower hospitalization rates in lines 316-318.

Line 339-441: I suggest deleting this sentence or reword it as, "Though it remains to be tested, these results suggest that policies that promote community well-being may also reduce hospitalization rates." As currently written, it is too complex.

Response: We agree with your assessment and we have revised the sentence as suggested (lines 443-445).