

# When a Straight Line Is Not the Most Direct Method: an Evaluation of Straight Line Versus True Distance Metrics for Patients in Rural Settings



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## Abstract

*Telehealth has been hypothesized as a solution for rural barriers precluding access to healthcare, of which distance remains one of the most significant. Providers, institutions, and policymakers may use distance as a metric to determine whether to keep, or to end, telehealth services. Although commonly used, straight line distance (SLD) may not reflect the true burden of distance (TD) for rural patients. A retrospective record review was conducted to determine the difference between SLD and TD for patients seeking behavioral health care at a large outpatient center. The discrepancy between SLD and TD ranged from 0.5 to 83.4 miles of additional travel distance (mean = -17.6). The mean percentage that SLD underestimated TD was 31.9%. Findings highlight that when considering distance as a determining factor for telehealth services, SLD is an inaccurate representation of the travel burden on this sample of rural patients, suggesting the utility of TD as an alternative.*

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## Introduction

Despite ongoing efforts to address mental health disparities throughout the USA, nearly 135 million Americans continue to reside in mental health shortage areas, with a majority living in rural locations.<sup>1,2</sup> Among the numerous barriers to rural care, distance to services is a primary contributor; patients living further away from healthcare centers have poorer health outcomes.<sup>3</sup> As high-speed internet became more readily available, cheaper, and stable in non-urban locations, telehealth, or the integration of technology with healthcare services (e.g., video, telephone, email), became a frequently suggested method of reaching those who have historically gone without care.<sup>4</sup> Telehealth has the potential to provide evidence-informed clinical services to remote locations while bypassing common obstacles, such as transportation issues, financial factors, disability, lack of providers, travel time, and time constraints.<sup>5</sup> Recognizing the utility of telehealth throughout COVID-19, governmental regulatory changes occurred to not only loosen regulations surrounding telehealth use in clinical services, but to also foster parity of reimbursement among insurance panels. Policies proved successful, with both general and specialized mental health services being available and accessible to a wider audience than ever before.

Despite increased availability, the World Health Organization and multiple researchers have highlighted that a patient's physical traveling distance to the location of service remains a critical influencing factor (or barrier) for patients' adoption of telehealth.<sup>6-8</sup> Historically, to evaluate distance to care, research has utilized a straight-line distance (SLD) approach. SLD calculates the distance between the center of the patient's zip code of residence and the center of the zip code for the treatment clinic, creating a straight line that represents the road lengths traveled along a road network connecting two points.<sup>9,10</sup> While a helpful metric, the commonly used strategy has been suggested as variable in accuracy and precision.<sup>9,10</sup> This is especially problematic for populations in rural locations that often cannot take a direct, straight-line approach to reaching a healthcare center. Many rural states within the USA have time-added considerations that are not factored into the SLD, such as mountainous regions and winding roads requiring extra mileage and slower speeds.<sup>9</sup> For these environments, a straight line can be misleading and misrepresent the "true distance" (TD) that a patient must drive to reach the provider.

Limited data is available on the factors that policymakers use to evaluate the provision of telehealth service;<sup>11</sup> though as distance to care is important for patients, it should be considered. However, providers, agencies, and policymakers may make misinformed decisions about the impact of distance on rural populations if they consider SLD, underestimating the burden of the TD in mileage, time, and other associated costs (e.g., gas, time away from work with lost wages).<sup>12</sup> These decisions can create availability or limit telehealth services for millions of Americans living in rural areas, especially for organizations considering the economic benefits of technologies at reducing patient-related costs in decisions to start, continue, or decide to end the provision of telehealth service.<sup>13</sup>

Ultimately, additional distance-related variables are present for rural populations that may continue to make them ideal telehealth candidates, even if they may appear "close enough" on a map. Although discussed within the literature, limited research is available that quantitatively evaluated this phenomenon.

The purpose of the current study was to quantitatively clarify distance approximations among patients seeking mental health services (i.e., psychology, psychiatry, social work) at a large regional outpatient medical center when using SLD (i.e., without factoring in terrain) as compared to TD (i.e., with factoring in terrain). As limited data could be drawn upon with no known metric for significance, based upon available literature, it was hypothesized that the SLD method would result in underreporting of mileage compared to the TD method.

## Methods

A retrospective, record review methodology was utilized. The convenience sample included all prospective patients seeking either psychological, psychiatric, or social work services at a large regional outpatient behavioral health center in West Virginia. Individuals were included in the study if they submitted a form applying for behavioral health services between January 2021 and March 2021 that contained their zip code and indicated that they were interested in receiving any behavioral health service. Exclusion criteria were limited to individuals who did not provide a zip code.

The West Virginia clinic was utilized as it served a research-desired rural population that frequently faces barriers to care. More specifically, West Virginia was ranked 29th on state accessibility to mental healthcare within the USA.<sup>14</sup> All prospective patients seeking services within the designated time frame, of the designated specialty services, and that provided zip codes were included in the analyses. Prospective patients were used in this study as the authors were interested in the distance to care for people who were considering behavioral health services.

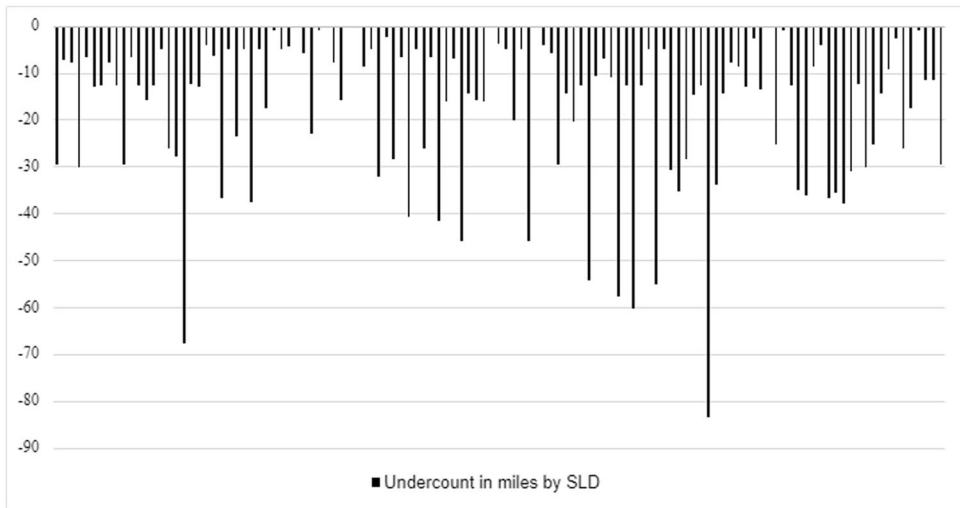
Zip code data was extracted by hand from initial intake forms by the authors after the close of the study period (April 2021). The final sample included 120 individuals who reported living in 70 different zip codes from across the state of West Virginia ( $N = 101$ ) and surrounding states (Pennsylvania,  $N = 9$ ; Maryland,  $N = 8$ ; Washington, DC,  $N = 1$ ; Ohio,  $N = 1$ ) which comprise the clinic catchment area.

Study variables included straight line distance (SLD) and true distance (TD). SLD is operationalized as the length of a straight line between the center of the patient zip code and the behavioral health site address. SLD was calculated from patient zip code to office zip code using the Zip Code Distance Database,<sup>15</sup> which calculates great-circle distance using the Haversine formula.<sup>16</sup> TD is operationalized as the length of the actual trip in mileage, the driving distance from the center of the patient zip code to the behavioral health site address. TD was calculated by entering the zip code and the behavioral health center address into Google Maps.<sup>17,18</sup> When multiple routes were suggested, the algorithm's preferred/direct route was utilized with the following specifications: (a) utilized non-toll roads only and (b) utilized routes that did not involve restricted access or private roads. SLD was compared to TD to find mileage discrepancy.

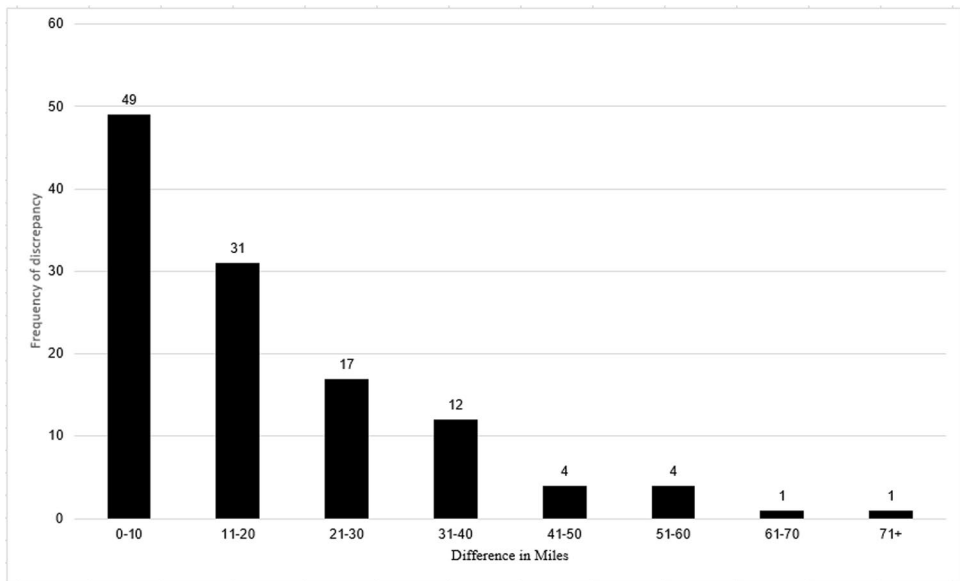
IRB acknowledgement was received by the Institutional Review Board at West Virginia University for protocol 2,110,453,245.

## Results

One hundred and twenty patients sought specialty behavioral health services, met inclusionary criteria, and were included in analyses. Using SLD estimates, patient distance from the clinic was between 0 and 178 miles ( $mean = 45.7$  miles,  $SD = 40.9$ ). Comparatively, using the TD method, patients were found to be traveling between 1 and 262 miles to the clinic location ( $mean = 63.4$  miles,  $SD = 55.2$ ). The difference between SLD and TD for each patient was calculated ( $mean$  discrepancy =  $-17.6$  miles,  $SD = 16$ ) and ranged from 0.5 to 83.4 miles of additional actual travel distance. Please see Fig. 1 for full sample distribution. Figure 2 shows the frequency distribution of the additional mileage required for TD. The percentage that SLD underestimated TD was also calculated ( $mean = 31.9\%$ ). Eighteen individuals had their TD underestimated by less than 10%, 40 individuals between 10 and 20%, 27 individuals between 20 and 30%, 10 individuals between 30 and 40%, 11 individuals between 40 and 50%, two individuals between 50 and 60%, and 11 individuals between 90 and 100%.



**Figure. 1**  
Difference between straight line distance and true distance



**Figure. 2**  
Frequency of mileage discrepancy

## Discussion

The current study sought to quantitatively evaluate SLD and TD estimates to determine if SLD appropriately represented or underestimated the distance that a rural individual must travel to reach a healthcare center within a rural state. The primary hypothesis was supported, with data highlighting the impact that terrain can have for individuals seeking healthcare from rural areas. For example,

mountain roads, unpaved roads, and private roads can prevent a direct approach, which not only adds mileage, but time for those seeking care. Such an effect was represented through the data suggesting an average difference of 17.4 miles between SLD and TD among the 120 patients seeking behavioral health services. Further, nearly 50% of patient data had a discrepancy of more than 10 additional miles between SLD and TD. Mileage becomes increasingly concerning with findings that of the total sample, nearly 34% of the sample had greater than 21 additional miles between SLD and TD. When considering that some mental health-focused treatments (e.g., therapy) require weekly or bi-weekly appointments, the differences between SLD and TD become even more marked.

## Implications for Behavioral Health

Access to behavioral healthcare is an increasingly difficult challenge to overcome in rural areas due to provider and resource shortages, as well as accelerated clinic closures.<sup>19</sup> Compounding availability, distance is a significant contributing factor that limits access to behavioral health services. These barriers could lead to the decision for rural individuals to not seek behavioral healthcare services. Current findings highlight that when distance is a consideration for providers supplying telehealth services, using SLD is an inaccurate representation of the travel burden on this sample of rural patients and TD must be considered. For some patients, adding multiple miles may be a determining factor in their ability to access services. For example, specific mental health disorders may limit motivation or ability to travel at all.

To ensure accessibility to evidence-informed care, telehealth services remain vital. Not only can telehealth bypass distance-related barriers, but other travel-related complexity, including inclement weather, patient or family member disability, childcare issues, employment time considerations, and finances for gas or parking fees for certain locations. Using child-focused treatments as an example of complexity, driving a child to treatment can include behavioral outbursts during travel, frequent stops, disruptions to the driver, and even safety concerns, each of which can limit a family's willingness to travel for care. Taken together, appropriate estimates (i.e., TD) of an individual's or family's travel distance, especially if it is a factor in determining the availability of telehealth services, remain essential.

While the current study was believed to present a critical assessment of SLD as compared to TD, the study is not without recognized limitations. First, the presented data is unique to the sampled population in West Virginia. Although the study's focus on mileage unrelated to specific demographics was believed to be addressed by the data, it is recognized that future work would benefit from a larger sampling to not only clarify regional differences, but to critically evaluate demographic factors (e.g., age, gender, race, ethnicity, religion) that may contribute to geographical differences. Second, the current study did not examine all possible contributing factors of terrain-related challenges (e.g., stop lights, areas known for high-levels of construction). Similarly, the current study did not directly evaluate other factors affecting telehealth selection among providers or barriers for patients (e.g., finances, attitudes towards treatment, disability), suggesting a need for expansion of current methodology to also include non-terrain factors. Finally, though this study explored the differences between methods of assessing travel via mileage, it is recognized that the actual time of traveling, whether SLD or TD, is an additional, and potentially more important, factor when considering one's travel to services. This time could include the role of weather at different times of the year, (un)planned construction, road quality, and other factors that could reduce or lengthen travel times even if the mileage remains unchanged. As a result, future work should further clarify the role of time (in minutes or hours) in addition to mileage traveled.

The current study was viewed as a preliminary evaluation to clarify a common metric used to justify telehealth in rural populations. Data indicated that SLD underrepresented the distance that

a rural individual must travel within the examined rural state when considering terrain that does not allow for a straight-line route. While additional study is required to further clarify distances of other locations both inside and outside of the USA, the current research does suggest that providers, agencies, and policymakers should consider utilizing a TD approach instead of an SLD approach when making decision regarding telehealth care for individuals living in rural and other underserved areas. Ultimately, the fastest and most direct straight distance may simply not be possible, with notable implications for behavioral health access and policy.

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#### Declarations

**Disclaimer** The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

**Conflict of Interest** The authors declare no competing interests.

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