Potential Influential Factors of Cognitive Decline and Engagement in Participants of Adult Day Services

Lauren Elms, Cat Hayes, Will Shelburne

Acknowledgements

The authors would like to thank Ila Schepisi, Jonathan Briganti, Dr. Anne Brown, and Dr. Benjamin Katz for providing the initial research focus and contributing insight and technical support as the study continued.

Abstract

As the global population of older adults increases, so does the need for more affordable caretaking services such as Adult Day Services (ADS) at Virginia Tech. Data collected over a 10-year period was assessed to understand factors affecting the quality of life for ADS participants. Two questions were posed: is there a relationship between blood pressure and cognitive decline over time, and is there a relationship between engagement levels and depressive symptoms? We hypothesized that increased blood pressure would correlate with increased mental decline, and that higher engagement levels would correlate with less depressive symptomology. To measure this, the dataset, which contains daily measurements and quarterly assessments, was cleaned and visualized using Tableau software. Due to software limitations and time restraints, it was not feasible to answer the blood pressure question in the time allotted. Instead, we researched the baseline relationship between blood pressure and indicators of cognitive decline and found no significant correlation between these factors. However, the results illustrated interesting variation in cognition scores over time. ADS participants’ first individual MMSE scores are unusually high compared to their average score, and the facility-wide average MMSE score has steadily declined over time. In answering the engagement question, we found a weak correlation between active participation and lower depressive symptomology ($R^2=0.0667$), and between passive and non-participation and higher depressive symptomology ($R^2=0.0140$ and $R^2=0.1742$, respectively). This research does not provide implications considering blood pressure but does show that MMSE
administration may need evaluation. Additionally, adult caretaking services may combat depression by encouraging active participation among its participants.

Introduction

As global life expectancy increases due to advances in technology and medicine, so too does the need for affordable caretaking services for older adults. Adult caretaking services, whether they are assisted living residences, day centers, or in-home hired help, have been designed to ease some of the burden from family caretakers while ensuring the needs of the older adult are met. Daytime facilities specifically are a cost-effective way to provide the caretaker with respite while also allowing the older adult to continue living in their own home.

Another advantage of caretaking facilities as opposed to home-care is that trained medical professionals may be staffed to monitor participants’ health. This allows the older adults to continuously be screened for predictive markers of many health problems, including diseases associated with decreased cognitive function, such as Alzheimer’s Disease (Zhu et. al, 2013). Scientific literature has shown relationships between physical markers, such as blood pressure, and cognitive decline. This is to be expected, as cognitive function is dependent on blood flow to the brain, and non-optimal blood pressure would restrict blood flow. If a characteristic relationship between blood pressure and cognitive function were identified, medical practitioners and geriatric care center staff would be able to recognize and engage high-risk individuals in preventative lifestyles and practices, possibly limiting treatment costs down the road.

A review of the literature shows inconsistencies when reporting the relationship between blood pressure and cognitive decline. Generally, a positive correlation between cardiovascular illness, specifically hypertension, and cognitive decline is reported. However, many studies have
produced conflicting results: some show data displaying negative correlations, and others show data displaying a J-curve relation, in which the J-curve trend is a transition from an inverse relation between cognition decline and low blood pressure to a direct relation between cognition decline and high blood pressure. This means cognition improves the closer a participant is to the range of ideal blood pressure values. A meta-analysis of these same studies determined that longitudinal data are the most consistent, as this decreases the impact of participants entering and exiting the program or research study (Duran & Hanon, 2008). Typically, those with high mental decline and high blood pressure do not participate in studies, as their health prevents them from joining in that state. Those that do participate with these conditions often prematurely drop out of the study due to unwillingness to participate, caused by their mental decline. This skews data to include only those who did not drop out. This phenomenon is known as “dropout differential”. Unfortunately, the subjects that drop out are typically those of the greatest interest to the researchers.

With reliable medical data, adult day centers have the potential to be crucial assets in improving the health and livelihood of older adults. However, these impacts on the participants have not been well studied. A review of the literature showed many studies focused on the effects of day services on the caretakers of older adults; fewer studies focused on the participants themselves, and of these, the majority researched ways to increase engagement in activities, the capabilities of older adults to improve mental function, and physical markers, such as sleep habits. Very few studies focused on improving the quality of life of participants through daily activities and participation levels. One study showed dementia support groups can lower behaviors associated with depression, but results were not statistically significant (Fields,
Anderson, & Dabelko-Schoeny, 2014). There is a significant gap in the literature relating to the effects of daytime caretaking services on the quality of life for the participants.

Our study addresses these inconsistencies by posing the following two questions: is there a relationship between blood pressure and cognitive decline, and is there a relationship between engagement levels and depressive symptoms? We hypothesized that increased blood pressure would correlate with increased mental decline, and that higher engagement levels would correlate with decreased depressive symptoms. We analyzed primary data collected over ten years from Adult Day Services at Virginia Tech (ADS) to assess the relationships between these factors.

Methods

To facilitate our analyses, we cleaned and organized the data collected by the Adult Day Services at Virginia Tech (ADS) staff and volunteers using Tableau software. This data was a collection of formal assessments and daily logs detailing the cognitive and daily functions of the participants. Because of the variety of metrics and measures, the data was organized into smaller subsets. The information and data subsets specific to our developed research questions were the daily blood pressure measurements, activity types, and participation levels from the Flowsheet data, the scores from the Mini-Mental State Examination (MMSE), the total scores from the Geriatric Depression Scale (GDS), and the total scores from the Life Satisfaction Scale (LSS). Blood pressure measurements were taken by a nurse or Certified Nursing Assistant on a voluntary basis at an unscheduled time each day. Activity type and participation levels were recorded once per activity for up to ten activities per day by ADS staff or volunteers. The activity type listed the name of the activity performed, and the activity participation described the level
of participation in that activity. The participation levels possible were: active, passive, resting, or other, where “other” described a situation in which a participant left the ADS-scheduled activity to do something else in the facility. The LSS and GDS were formal assessments to screen for depressive symptoms and were administered individually to each participant by ADS staff roughly every six months. A higher GDS score indicates higher depressive symptoms, while a higher LSS score indicates lower depressive symptoms. The MMSE (1st edition) assessed for changes in cognitive functioning over time and was administered at time of enrollment and every six months afterwards by ADS staff. A lower MMSE score indicates decreased cognitive functioning.

The blood pressure measurements, MMSE scores, and LSS scores were used to assess the relationship between blood pressure and cognition. The activity type and participation measurements, GDS scores, and LSS scores were used to assess the relationship between engagement in ADS activities and depression.

To begin the engagement analysis, data from the GDS and LSS were assessed. The scores from the LSS and the GDS of each participant were plotted over time as a preliminary visualisation to determine if the two tests indicated similar levels of depressive symptoms. Then, average LSS and GDS scores were plotted against the number of days their respective participants attended ADS to see if there was a correlation between length of participation in ADS and depressive symptoms. To assess the activity engagement data, it was necessary to consolidate all activity types and participations levels for each participant, as the method of data collection had arbitrarily divided the activities throughout each day. After this consolidation, the participation levels of each participant were manipulated to be shown as percentages of total
participation, which was made up of active, passive, and resting participation. This fractionation
excluded the “other” participation level. The average GDS and LSS scores were plotted against
each participant’s fractions of active, passive, and resting participation. Lastly, the GDS and LSS
scores were plotted against their respective participants’ fractions of active participation over
time. Active participation, as opposed to passive or resting participation, was selected for this
graph, as we wanted to determine if there was a relationship between active participation and
depressive symptoms.

Blood pressure values were split into separate diastolic and systolic values and averaged
over a three month timespan to divide the values into quarters. The overall MMSE scores were
also averaged into quarterly time periods. The MMSE and blood pressure values were matched
together based on participant IDs and were graphed over time to observe trends in each
individual participant. Then, the first quarter values for each participant were plotted (BP versus
MMSE score) to assess trends in order to calculate correlation. This procedure was repeated with
LSS scores to yield a BP-LSS comparison. Lastly, the overall average MMSE score of ADS was
compared to average overall blood pressure by year. This last analysis led to further questions
about the facility's average yearly MMSE scores, so box and whisker plots were constructed to
look at data distribution and outlier presence.

**Results**

*LSS/GDS correlation*

To determine the relationship between the LSS and GDS as administered by ADS staff,
the scores for each participant were plotted relative to the month the assessment was
administered (Figure 1). This produced a basic inverse correlation. Because a higher GDS score
and a lower LSS score both indicate higher depressive symptoms, this inverse correlation suggests that each assessment reported a relatively similar level of depressive symptoms.

**Figure 1:** The scores of the GDS and LSS for each participant plotted over time indicate a roughly inverse correlation. The GDS score is represented by the blue line and is measured on the axis on the left. The LSS score in represented by the orange line and is measured on the scale on the right. This figure shows participants with at least 18 months’ worth of data. (N=22)

**LSS/GDS length of stay**

Average LSS and GDS scores were plotted against the length of stay in ADS for their respective participants (Figure 2). This showed a very weak correlation between a longer period of time at ADS and less depressive symptoms.
Figure 2: The Average LSS and GDS scores are plotted against length of stay, with the trend line included. Each blue circle represents an individual participant within ADS at Virginia Tech. A) LSS data with correlation coefficient equal to 0.0129. B) GDS data with correlation coefficient equal to 0.1726 (N=73)

LSS/GDS participation fractions

Average GDS and LSS scores were plotted against each participants’ fractions of active, passive, and resting participation. Both figures showed a weak correlation between higher fractions of active participation and lesser depressive symptoms, whereas there was a weak correlation between higher fractions of passive and resting participation and increased depressive symptoms. (Figures 3, 4).
Figure 3: The average LSS score versus fractions of participation levels per participant shows very weak correlations. A higher LSS score indicates decreased depressive symptoms. A.) The average LSS score versus the fraction of active participation produces a correlation coefficient of 0.0667. B.) The average LSS score versus the fraction of passive participation produces a correlation coefficient of 0.0140. C.) The average LSS score versus the fraction of resting participation produces a correlation coefficient of 0.1742. (N=76)
The average GDS score versus fractions of participation levels per participant shows very weak correlations. A higher GDS score indicates increased depressive symptoms. A.) The average GDS score versus the fraction of active participation produces a correlation coefficient of 0.0456. B.) The average GDS score versus the fraction of passive participation produces a correlation coefficient of 0.0090. C.) The average GDS score versus the fraction of resting participation produces a correlation coefficient of 0.1669. (N=70)

**Figure 4:** The average GDS score versus fractions of participation levels per participant shows very weak correlations. A higher GDS score indicates increased depressive symptoms. A.) The average GDS score versus the fraction of active participation produces a correlation coefficient of 0.0456. B.) The average GDS score versus the fraction of passive participation produces a correlation coefficient of 0.0090. C.) The average GDS score versus the fraction of resting participation produces a correlation coefficient of 0.1669. (N=70)

**LSS/GDS active participation fraction over time**

GDS and LSS scores were plotted against their respective participants’ fractions of active participation over time. The GDS data showed a weak correlation between higher fractions of
active participation and lower depressive symptoms (Figure 5). The LSS data, however, was inconclusive (Figure 6).

**Figure 5:** Although no statistical tests were done, the GDS scores versus fraction of active participation over time seem to produce an inverse correlation in most cases. The purple bars represent the GDS scores, as measured on the axis to the left. The blue lines represent the fraction of active participation, as measured on the axis to the right. This figure is a sample of the full graph that included only participants with at least two GDS scores. (N=13)
Figure 6: Although no statistical tests were done, the LSS scores versus fraction of active participation over time seem to be inconclusive, and no conclusions were drawn from this figure. The green bars represent the LSS scores, as measured on the axis to the left. The blue lines represent the fraction of active participation, as measured on the axis to the right. This figure is a sample of the full graph that included only participants with at least two LSS scores. (N=25)

Difficulty directly comparing blood pressure and cognition deficits over time

Comparing blood pressure and MMSE score over time was inconclusive due to time restraints and software limitations (Figure 7). Data cleaning for the blood pressure took longer than expected, as we had to somehow average the data, match data points according to ID and quarter, and decide a timeline or time limit. Tableau could not directly compare two factors over time or required intricate coding to do so, as illustrated by Figure 7 as it only contains blood
pressure values. Due to these problems, we decided to analyze the baseline relationship rather than focus on answering the research question over time.

**Figure 7:** Analysis of blood pressure values over time did not lead to any significant results, and due to software limitations we were unable to directly compare blood pressure and cognition scores using this type of graph. The blue line represents average systolic pressure, and the orange line represents average diastolic pressure. This graph only included participants with greater than 1.5 years of blood pressure data, and the points were averaged quarterly. (N= 32)

**Lack of baseline relationships when comparing blood pressure and other factors**

Blood pressure and MMSE scores did not exhibit any significant baseline relationship ($R^2 = 0.00187$, Figure 8). This graph only includes the data from individuals with greater than 1.5 years of blood pressure and MMSE scores, and only the first quarter scores were paired and graphed. Similarly, the blood pressure and LSS scores did not show any significant baseline relationship ($R^2 = 0.000806$) with the same parameters (Figure 9).
Figure 8: No significant relationship ($R^2 = 0.00187$) was identified when average MMSE scores were compared to average systolic blood pressure scores, according to ADS participant ID. The graph only included participants with greater than 1.5 years of blood pressure and MMSE scores. (N= 32)
Figure 9: No significant relationship ($R^2 = 0.000806$) was identified between average systolic blood pressure values and LSS (Life Satisfaction Scale) scores, according to ADS participant ID. The graph only included participants with greater than 1.5 years of blood pressure and MMSE scores. (N= 32)

*Yearly comparison of MMSE scores yields interesting results for recent years*

A comparison of facility-wide yearly average blood pressure and MMSE scores illustrated that blood pressure values are remaining clustered/constant, while MMSE values have dramatically dropped for 2016, 2017, and 2018 (Figure 10). The discovery of this recent decrease led to further analysis of MMSE score variation and change over time.

Figure 10: A comparison of yearly average MMSE score versus yearly average blood pressure yielded no significant change in blood pressure values, but did illustrate a recent drop in MMSE scores from 2016-2018. These three values are seen at the bottom on the graph in darker blue colors. The values in this graph were created by calculating the ADS facility-wide average blood
pressure values and MMSE scores by year, only utilizing participants who had 1.5 years of MMSE score and blood pressure values (N = 32).

MMSE scores show potential to study causation behind recent decreased averages

Box and whisker plots were created to examine MMSE score distribution and outlier presence over time. These plots were done with two different data sets; the first only graphs participants with more than 1.5 years of MMSE scores, and the second graphs all participants that had MMSE data (no time constraints). Figure 11 shows a two phenomena: a decrease in participants with higher average MMSE scores and a general lack of data for 2016, 2017, and 2018. Figure 12, however, more clearly shows that the overall average yearly score, with a potential skew towards lower scores. Figure 11 and Figure 12 revealed zero outliers and one outlier, respectively.
**Figure 11:** A box and whisker plot of yearly average MMSE score by participant ID exhibited lack of data and a decreased amount of high score averages for the years with decreased overall MMSE score averages (2016, 2017, and 2018). This graph only includes participants with MMSE data greater than 1.5 years (N= 32).

**Figure 12:** A box and whisker plot of yearly average MMSE score by participant ID exhibits a decreased yearly median, with a possible skew towards lower scores in the years with decreased overall average MMSE scores (2016, 2017, and 2018). This plot had no time filters as long as the participant had at least 1 MMSE score (N= 89).

**Discussion and Conclusions**

Although more statistical analysis is necessary to confirm the results from this study, preliminary conclusions from the blood pressure/cognition portion and engagement/depression
portion can be drawn to begin filling some gaps in the literature pertaining to factors that affect the quality of life in daytime caretaking facilities and the measurement of predictive markers of cognitive decline. It is possible that adult caretaking centers may counter depression and depressive symptoms in its participants by encouraging active participation and scheduling activities that are of personal interest to the participants. Future researchers may be able to use this preliminary blood pressure data as a starting point to answer the original research question about the impact of blood pressure on cognition over time. Additionally, ADS at Virginia Tech may need to evaluate MMSE administration and participant withdrawal rate. It is possible that older adults coming in with lower MMSE scores may also be limited on their ability to participate in engagement activities, so a follow up with both the engagement and MMSE score average data may lead to results that further answer our research questions. Given more time, we would have studied the variation in of participant’s MMSE scores over time to draw conclusions about the cause of lowered facility averages, and we would have done more analysis comparing the systolic and diastolic data sets to various factors. We would also have examined specific activities, such as exercise and cognitive games, to determine if there was a correlation between active participation and depressive symptoms.
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