Where Robots Can Fit In: A Systematic Review of the Incidence of Comorbid Dementia and The Prescribed Treatments

Matthew Sawchuk
Department of Computer Science
University of Minnesota Duluth
Duluth, USA
sawch013@d.umn.edu

Arshia Khan
Department of Computer Science
University of Minnesota Duluth
Duluth, USA
akhan@d.umn.edu

Abstract—(1) Background: The purpose of this systematic review is to find the incidence of dementia in adults with cognitive, developmental, or physical disabilities and the prescribed treatments for those comorbidities. The findings will be used to determine the possible interventions for robots in the treatment for comorbid dementia. (2) Methods: The studies included in this review focused on the incidence of dementia among various disabilities and the prescribed treatments, published between 2018 and 2023, written in English, and have full text availability. The databases used to collect the sources for this review were Academic Search Premier, Gale Academic Onefile, PubMed, Google Scholar, Web of Science, ProQuest, and Scopus. Furthermore, data was collected through hazard ratios (HR), adjusted hazard ratios (aHR), cases per number of people-years, and percentage based on sample size or population. No methods were selected to determine the risk of bias for the sources. (3) Results: The methods of this review produced 30 sources to be included in the results. The highest hazard ratios for the incidence of dementia depending on disease type are mild behavioral impairment (MBI) with HR 8.07, mild cognitive impairment (MCI) HR 7.05, and subjective cognitive decline (SCD) with HR 6.81. These results are mostly consistent with the findings for the cases per person-years data. Finally, the highest comorbid illnesses with dementia, in terms of population size, are type-2 diabetes (45.92%), type-2 diabetes with hypertension (43.60%), and depression (42.90%). (4) Discussion: The incidence of dementia is strongly correlated with the severity of cognitive impairment caused by a disease. Furthermore, the best instances where robots can fit in during the treatment and prevention of dementia is through exercises that promote cognitive function. (6) Funding: This systematic review received no external funding.

Keywords—dementia, systematic review, comorbidity, incidence, dementia treatments, alzhiemers disease, robots, robotics.

I. Introduction

The growth of the medical industry has increased the average lifespan for adults. Coincidentally, the incidence of dementia has also increased because cognitive impairment (CI) is associated with old age. The conversion from the initial diagnosis of mild cognitive decline (MCI) to dementia after a single year is 18.4% [1]. Furthermore, the rate of conversion from MCI to dementia increases as the duration and severity of MCI increases over time [2]. A developing field of research is looking into the incidence of dementia alongside different cognitive, developmental, and physical disabilities. Robotics is another growing field of technology that can provide many benefits to healthcare applications, such as portable and affordable assistance in elderly care, recovery, and hospital settings.

The field of epidemiological studies with a focus on the incidence of comorbid dementia is expanding. One review suggested that depression may be one of many modifiable risk factors for preventing and or delaying the onset of dementia [3]. An additional review linked various common risk factors between dementia and various other disabilities, including both modifiable and non-modifiable risk factors [4]; however, additional research must be conducted to preview the large scale incidence of dementia among people with cognitive, developmental, and physical disabilities. One of the areas that are heavily lacking in the current literature are studies that look at treatment interactions for an illness on dementia or the development thereof. Though current pharmaceutical studies exist that support many treatments for comorbid dementia, few studies have looked into non-pharmaceutical treatments for comorbid dementia. To our current knowledge, no previous study has been performed to look into robotic interventions during the treatment of comorbid dementia for patients. Therefore, in addition to finding the incidence of dementia among cognitive, developmental, and physical disabilities, the purpose of this systematic review is to analyze the current literature on treatments for comorbid dementia that robots can intervene. The first objective of this review is to see which diseases or disorders have the highest incidence for dementia. Additionally, the second objective of this review is to survey the current treatments for comorbid dementia that robots can intervene with and determine the ethics behind these interventions.

II. Materials and Methods

A. Protocol and Registration

The present systematic review follows the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-

979-8-3503-2759-5/23/$31.00 ©2023 IEEE
DOI 10.1109/CSCE60160.2023.00234

Analyses (PRISMA) Statement. No adjustments were made to the PRISMA format in this systematic review.

B. Eligibility Criteria

- **Non-pharmaceutical.** Pharmaceutical studies were marked ineligible since non-drug related interventions where robots can be placed were of greater value to this review.
- **Written in English**. All reports included in this review were to be writen in English to prevent translation issues.
- **Published between 2018 and 2023**. All reports must be published between 2018 and 2023. This is to ensure the quality of the findings are relevant to the current applications of dementia research.
- **Open Full Text Availability**. All reports must have full texts available that are both accessible and free.
- **Information Sources**. The following is the list of databases and the dates used to gather sources for this review: Academic Search Premier, January 6, 2023; Gale Academic Onefile, January 9, 2023; PubMed, January 9, 2023; Google Scholar, January 10, 2023; Web of Science, January 23, 2023; ProQuest, January 26, 2023; Scopus, January 27, 2023.

The primary keywords used in this systematic review are as follows: dementia or dementia incidence, mental disability or disorder, cognitive disability or disorder, developmental disability or disorder, physical disability or disorder, comorbidity, incidence, and treatment or treatments. The query string varied slightly among the various databases due to the lack of results one string would provide over another. For instance, ProQuest did not provide any reports when given the string "(dementia) AND (((mental OR cognitive) OR developmental OR physical) AND (disability OR disorder)) AND incidence AND (treatment or treatments)," where Scopus provided many. Instead, for the databases that did not provide any sources given this first string, the secondary string, "dementia incidence AND comorbidity AND treatments," was used.

An example search using the methods in this review is conducted through Scopus. Using the "TITLE-ABS-KEY" command and the string "(dementia) AND (((mental OR cognitive) OR developmental OR physical) AND (disability OR disorder)) AND incidence AND treatment*" provides 1090 reports. This search is refined by setting the publication year range to be between 2018 and 2022. Furthermore, the subject area was limited to neurology and psychology, the language was set to English, and the state of the publication was set to "final." After refining the search using these constraints, 39 reports are left remaining. This approach was conducted similarly on all other databases included in this review.

C. Study Selection

The reports in this review, after being collected from the databases, underwent three stages of screening: title and abstract screening, full text availability, and content screening.

1) Title and Abstract Screening

All reports underwent this first step of screening, which involved looking through the titles and abstracts of the reports. If the content of the titles or the abstracts did not fit the criteria of this study, they were rejected and did not proceed to the other two steps.

2) Full Text Availability

After going through the Title and Abstract Screening stage, the reports were then screened for their full text availability. If a full text was available for a certain report, then its PDF was downloaded and the report proceeded to the Content Screen stage. Otherwise, the report was rejected and did not continue with the third and final stage.

3) Content Screening

If reports successfully passed the previous two steps, then the entire contents of the reports were screened. The study objective, methods, and discussion were the primary locations where the reviewer would decide whether or not to include a study in this review. If the content of a report fit within the context of the review, then it was included in the data collection process. The following is the list of reasons why reports were excluded from this review: (1) report was a review, (2) report did not discuss the incidence of comorbid dementia nor corresponding treatments, (3) report has not yet been conducted, or (4) report focuses on resulting illness from dementia. The selection process was conducted by a single reviewer. This decision was made in order to limit differences in discretion between the inclusion of different reports.

D. Data Collection Process

The reports that remained after the screening stages underwent the data collection process. During this process, the methods, results, and discussion sections of the reports were evaluated. The data that was gathered involved the incidence of comorbid dementia and or the treatments for comorbid dementia. Similar to the study selection process, the data collection process was also conducted by a single reviewer. In the situation where multiple studies intersected on a single point of data, the average was taken between those studies.

E. Data Items

During the data collection process, the incidence of dementia was reported differently among the various studies. However, many studies included either the hazard ratios or 1000 person-years (or similar) of the incidence of dementia. Additionally, the treatment method was also noted if it was present in the study.

F. Risk of Bias

The primary risk of bias present in this study is due to the discretion of the single reviewer. A stronger method of preventing risk would involve multiple reviewers that gather sources independently. This alternative method was not selected because it was deemed unnecessary for the scope of this review. Additionally, no methods were used to assess the risk of bias.

G. Certainty Assessment

Although there was no standard practice of evaluating the certainty of the body of evidence in this review, the limitations

of each report were taken into consideration for how its evidence should be used. If the limitations outweighed the validity of the results, then the evidence provided by the report was used with high discrepancy.

III. Results

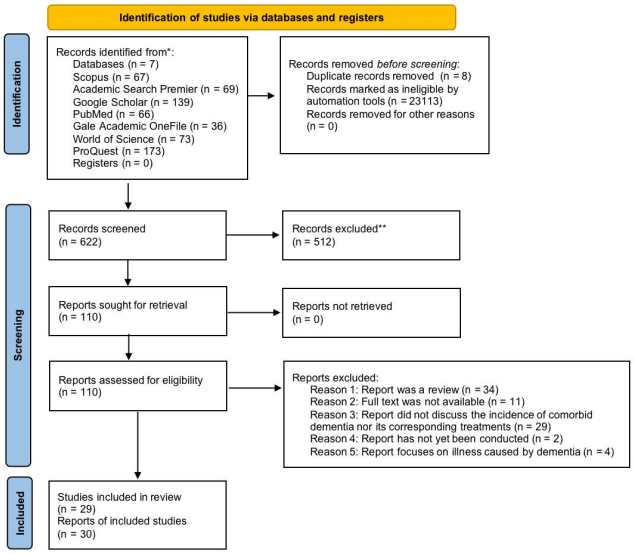

Fig. 1. PRISMA Flow Diagram. This figure shows a visualized review process for gathering sources under the PRISMA format.

TABLE I. Contributions of Studies

Contribution	Studies
Incidence	[1, 2, 5-11, 13-16, 18-32]
Treatment	[2, 12-20, 29, 31]

A. Study Characteristics

Incidence. Of the included studies, 28 reports (see TABLE I) discussed the incidence of comorbid dementia among various cognitive, developmental, and or physical disabilities. Hazard ratios were included in 10 studies to present the risk of developing dementia given a certain disability. However, of the studies that did not provide hazard ratios for the incidence of comorbid dementia, these studies either provided 1000 person-years or provided incidence based on percentage. Additionally, 17 reports focused on the development of Alzheimer's Disease, a dementia subtype, in response to a specified condition. On the other hand, two studies discussed the incidence of developing Huntington's Disease (HD).

Treatments. 12 studies among those included in this review provided information about treatments that are used to either treat or prevent dementia. The efficacies of these treatments were evaluated based on the changes of hazard ratios or cases of dementia compared to a control group. Among the 12 studies that discussed various treatment options for preventing dementia, five studies use their results from the studies of dementia to provide future work for dementia treatments. These types of treatments were not as heavily considered as the ones that were the main focus of other studies, which totalled to another six reports. The remaining studies either look into the incidence of certain kinds of treatments or provide evidence to not perform a certain kind of treatment.

B. Risk of Bias in Studies

All studies, with the exception of two studies, were cohort-based studies. The risks of biases were not evaluated for the studies unless they were mentioned in the limitations sections of the studies. One particular study [5] mentioned that due to the retrospective nature of their study, recall bias may present in their results. This kind of bias can be present in questionnaires, surveys, or during data collection from medical professionals because a patient may have forgotten to include a key piece of information. A similar point of view as the above mentioned study [5] has been assumed among the other studies that have performed a retrospective study or prospective study [2, 5-14, 29, 31].

Aside from the cohort-based studies, three studies included in this systematic review were trial-based [15-17]. None of the trial-based studies have mentioned any sort of biases that may be present in their results. One potential reason for this is the long-term nature of these studies and all of the studies focusing on re-obtaining cognitive function. Thus, no assumptions were made regarding these trial based studies.

C. Results of Synthesis

TABLE II. Hazard Ratios and Adjusted Hazard Ratios of Dementia Incidence Among Comorbid Illnesses

Illness	HRs and aHRs of Dementia Subtype with Comorbidities	
	Dementia	***AD***
MBI	/	/
HR	8.07	/
aHR	/	/
MCI	/	/
HR	7.05	/
aHR	/	/
SCD	/	/
HR	6.81	/
aHR	/	/
Sleep Disorder	/	/
HR	0.71	/
aHR	/	/
Depressive Episode	/	/
HR	1.4	/
aHR	1.286	/
Migraine	/	/
HR	1.05	1.14

Illness	HRs and aHRs of Dementia Subtype with Comorbidities	
	Dementia	*AD*
aHR	0.845	0.94
Stroke	/	/
HR	3.565	/
aHR	2.63	/
ETT-1	/	/
HR	/	/
aHR	2.37	2.59
ETT-2	/	/
HR	/	/
aHR	3.7	3.86
ITT	/	/
HR	/	/
aHR	3.63	4.11
DTT	/	/
HR	/	/
aHR	5.19	4.44
Depression	/	/
HR	/	/
aHR	1.832	/
Depression with SCD	/	/
HR	/	/
aHR	2.466	/
CVD	/	/
HR	/	/
aHR	3.12	/
Physical Frailty	/	/
HR	/	/
aHR	1.13	/
Cognitive Frailty	/	/
HR	/	/
aHR	3.43	/

*Sources included in this table: [6, 10, 18, 19, 21, 24, 47, 29]. Abbreviations: ETT-1 (easy-to-treat depression 1), ETT-2 (easy-to-treat depression 2), ITT (intermediate-to-treat depression), DTT (difficult to treat depression), CVD and (cardiovascular disease).

The results of the studies that have used HRs and aHRs can be found in Table II. It is important to note that many of the included studies have also used other dementia (Dem) subtypes. Alzheimer's disease (AD) was the only study that was selected because it is the most common dementia subtype. Furthermore, there was not enough data for other dementia subtypes that warranted the need to add them in Table II.

TABLE III. INCIDENCE OF DEVELOPING DEMENTIA AMONG COMORBID ILLNESSES

Illness	Incidence of Dementia Per 1000 Persons	
	Dementia Cases	*Per Persons*
MBI / Dem	236.5	1000
MCI / Dem	230.4	1000
Delerium / Dem	149.3	1000
SCD without MBI / Dem	107.9	1000
Delusional / Dem	88.7	1000
Other Psychiatric Disorder / Dem	28.8	1000
Other Psychiatric Disorder / HD	0.150	1000
Anxiety / Dem	27.1	1000
Depressive Episdoe / Dem	14.3	1000
Sleep Disorder	17.47	1000
Depression / HD	15.4	1000
PeDD with PD / Dem	34.2	1000
PoDD with PD / Dem	7.5	1000
Adjustment Disorder / Dem	6.4	1000
Migraine	5.9	1000
Nonorganic Sleep Disorder / Dem	7.23	1000
Insomnia / HD	0.37	1000
Somatoform Disease / Dem	6.49	1000
Migraine / Dem	3.98	1000
Migraine / VD	36.33	1000
Migraine / OD	53.87	1000
Psychosis / HD	7.93	1000
Dementia / HD	41.87	1000
Pneumonia / HD	20	1000
CVD / HD	236.5	1000
Hypertension / HD	230.4	1000
Diabetese / HD	149.3	1000

*Sources included in this table : [6, 18, 21, 32]. Abbreviations: Dem (dementia), HD (Huntington's Disease), PeDD (pre-diagnostic depression), PD (Parkinson's Disease), and PoDD (post-diagnostic depression), VD (vascular dementia), OD (other dementia).

According to the data collected in Table III, mild behavioral impairment (MBI) had the highest incidence rate for developing dementia compared to the other diseases. Second to MBI, mild cognitive impairment (MCI) is the second leading disease that leads towards the development of dementia. It is worth noting that the only disorder that is not based on cases per 1000 person-years basis is the comorbidity of other psychiatric disorders and Huntington's Disease (HD). This suggests that it is very rare for other psychiatric disorders to develop HD compared to other diseases, and it should be

worth considering that this does not include patient background information or family histories of the patients.

TABLE IV. INCIDENCE OF DEVELOPING DEMENTIA AMONG COMORBID ILLNESSES ON A % PER POPULATION BASIS

Illness	Incident Rates of Developing Dementia	
	Incidence	*Cases per persons*
ADHD / HD	5.20%	308
Anxiety / HD	12.30%	308
Depression / HD	42.90%	308
Diab Mel / HD	11.00%	308
Dysphagia / HD	28.60%	308
Mvmt dis. / HD	30.50%	308
Insomnia / HD	13.30%	308
Osteoarth. / HD	17.90%	308
Sys Atrophies / HD	2.60%	308
MCI / dem	22.42%	87, 250
MD / AD	3.73%	30578
Bipolar / AD	1.33%	30578
PTSD / AD	6.06%	30578
Anxiety / AD	1.50%	30578
Panic / AD	0.22%	30578
Phobia / AD	0.10%	30578
Alco. Ab. / AD	1.82%	30578
Drug Ab. / AD	0.32%	30578
Tobac. Ab. / AD	4.58%	30578
Psychosis / AD	3.07%	30578
SCHZ / AD	1.26%	30578
PD / Dem 90+	1.23%	110
PD / Dem 80-89	1.59%	110
Mood / FTD	19.00%	56296
Anxiety / FTD	20.00%	56296
Subst. / FTD	19.00%	56296

*Sources included in this table: [1, 7, 20, 23, 25]. Abbreviations: ADHD (attention hyperdefecit disorder), Diab Mel (diabetes melitus), Mvmt dis. (movement disorder), Osteoarth (osteoarthritis), Sys Atrophies (systemic atrophies), MD (mild dementia), Alco. Ab. (alcohol abuse), Drug Ab. (drug abuse), Tobac. Ab. (tobacco abuse), SCHZ (schizophrenia), Subst. (substance disorder), and FTD (frontal temporal dementia).

According to Table IV, the highest incidence of dementia based on comorbidity is MCI (22.42%). This result is consistent with the findings in Table 2, where MCI was one of the highest comorbidities associated with dementia. In terms of HD, the highest associated comorbidity is depression, which accounts for 42.90% of HD cases. As for AD, the highest associated comorbidity is PTSD, which accounts for 6.06% of the cases that were studied [7].

D. Reporting Biases

The purpose of this review is to determine potential interventions where robots can play a role in assisting patients dealing with comorbid dementia. Due to the availability of resources, the risk of bias among nearly all sources included in this review are at high risk of bias. Most sources included in this review are retrospective, population, and prospective based cohort studies, which most have a high risk of bias. Furthermore, most databases these studies use are based on medical insurance and self-reported data. In these databases, there is a high risk for recall bias and bias due to missing data. Since these studies were the most available, no standard assessments were used to evaluate the risk of missing data due to bias.

E. Certainty of Assessment

Similarly to the previous section, no standard assessments were used to determine the certainty of data collected from the sources included in this review. However, most of these studies include large population sizes that reach the requirements for statistical power. Therefore, it should be noted that while no assessment was used to determine the certainty of data, in addition to the risk of bias, the sample sizes of many of the studies are large enough to be statistically significant.

IV. DISCUSSION

The incidence of dementia increases for disorders that have cognitive impairing effects, such as mild cognitive impairment [1, 6, 23], mild behavioral impairment [6], depression [6, 10, 20, 21, 27, 32], migraines [18, 29], and strokes [19]. Additionally, the incidence of dementia seems to depend on the severity of the cognitive impairing effects of a particular disease. An example is the difference in brain altering effects that migraines inflict compared to strokes. Migraines, although painful, do not inflict the same damage as strokes when they occur. According to the incidences between migraines and strokes, strokes have a higher incidence of developing dementia [18, 19]. However, based on the limitations of most of the studies in this review, the incidences of dementia are only based on associations. This is apparent by the kinds of databases that were selected by most of the studies, which only include health insurance claims or self reported conditions. While associations can be made on this data, causation data would need information such as pre-dementia condition severity and length before onset dementia.

No major contradictions were found between most of the studies. The only differences that occurred were for incidence data, which the average was taken between the conflicting studies for a particular illness. The only areas where intersections between studies occurred were migraine, stroke, and depression for hazard ratios and only MCI for percentage-based dementia incidence.

A trend in the treatments for comorbid dementia, according to the studies in this review, was how the treatments targeted onset dementia and not for pre-existing dementia. This trend can be summarized by the saying “the best form of treatment is the prevention of the illness.” Additionally, these treatments place an emphasis on improving cognitive function and

preventing the onset of CI. Due to the high conversion rate from MCI to dementia, preventing cognitive impairment is key to delaying onset dementia. The treatments that will be discussed into further detail are the following: acupuncture, cognitive training, exercise, and choral singing.

A. Acupuncture

Various conditions, such as migraines, headaches and strokes, can eventually lead to the development of dementia in the long run. Multiple studies [18, 19] have suggested that acupuncture may be a promising treatment to prevent the long term cognitive impairment caused by conditions like migraines and strokes. One major limitation of these studies is that the acupoints nor their long term effects were not noted by the studies. A study has reported that acupuncture reduces the onset of dementia with an incidence rate (IR) reduction of 4.16, with the IR of no acupuncture treatment being 7.23 and the IR of acupuncture treatment being 3.07 [18]. Another study came to a similar conclusion in terms of aHRs when treating stroke symptoms (post-stroke no acupuncture: 3.723 aHR and post-stroke acupuncture: 0.529 aHR) [19].

While acupuncture poses a very promising treatment for delaying onset dementia, the ethics of robotic interventions should be heavily considered. It is highly not recommended to introduce robots in the acupuncture environment because of many serious concerns that include safety and fear responses. While safety is self explanatory, it is worth noting that robots are not precise enough for medical purposes unless they are modeled after industrial robots. This is only effective though, if the patients are relaxed during the procedure. This may not be the case in an acupuncture setting because robots, next to sharp, dangerous things like needles, can elicit fear in the patients. This also poses many ethical concerns that prevent recommending the use of robots in an acupuncture setting.

B. Cognitive Training

Cognitive training (CT) is a type of program that tries to improve cognitive function through various brain-related tasks. Computerized versions of CT can provide portable and effective ways to provide CT to many individuals with any degree of cognitive impairment (CI). One particular study utilized electronic CTs alongside exercise to reduce the incidence of dementia [15]. However, the effectiveness of this is limited by another study that could not build a sufficient claim to support computerized CTs for treating cognitive impairment [16]. This study did note its lack in statistical power, so computerized CT could not be either supported or rejected by this study.

An alternative to using computerized CT is to have robots perform the CT exercises with CI patients. A systematic review discussed the different applications where robots can fit during the CT exercises [34]. One of the primary implications of the aforementioned review is that while robots may be able to instruct these CT exercises, the replacement of human trainers or other methods should be taken into account. While robots can fit into CT exercises, factors like human dignity, frustration tolerance, and safety can be impacted based on the implementations.

C. Exercise

Many studies have shown that exercise is another effective way to reduce the onset of dementia in the long run [15, 20]. Within the context of robotic interventions, robots can provide an effective way to lead an exercise program without the need of hiring workout trainers. One study proved the effectiveness of socially assistive robots (SAR) when they assume the roles of exercise trainers for older adults [33]. Additionally, the effect trajectory of supplementing exercise alongside cognitive training decreases the incidence of dementia (0.62) [15].

D. Choral Singing

One of the pre-existing treatments for dementia is health education because education-level was found to be one of the many modifiable risk factors for dementia. However, one study has shown that choral singing might be an alternative to health education [17]. This study showed that choral singing can provide the same benefits as health education when improving cognitive impairment. Furthermore, this study suggests that choral singing should be used in conjunction or replacement to health education because choral singing also provides many rhythmic exercises and other music related exercises. Robots, with the combination of music-intelligent AI, can provide basic vocal exercises to participants at low cost. Additionally, robots can structure rhythm games that can provide many additional benefits aside from improved cognitive function.

E. Limitations

This systematic review has many limitations. The first limitation is the lack of specific research available for the goals of this study. There does not exist many studies, aside from literature and systematic reviews, that look at the incidence of dementia alongside physical, cognitive, and developmental disorders. Furthermore, the studies that do look at dementia incidences are mostly cohort based studies. While this method is robust for finding associations between dementia and other diseases, no causation data could be collected. Additionally, the databases did not have sufficient information to link pre-dementia disease duration or severity to onset dementia. Therefore, the accuracy of the data collected in this study is limited by important information that was not collected by those databases. Second, none of the studies included in this review have discussed treatments for already existing comorbid dementia. The only treatments discussed by some of the studies in this review are preventative treatments to delay the onset of dementia. Finally, this review did not have access to medical school source databases, which could have provided more meaningful data for the context of this review.

F. Review Implications

There is very little research that tries to look into treatments for comorbid dementia. Due to the increasing incidence of dementia, it is essential that more studies look into the interactions of treatments on comorbid dementia and the disorders alongside dementia. Additionally, longitudinal studies should be constructed to observe potential causations between disorders and dementia instead of associations. Most studies that have observed dementia retrospectively suffer recall bias due to the self report data in the databases used by those studies. Studies should also focus on lengthening the

observation time, whether that be through reviews or trials. This is because certain dementia subtypes, such as dementia with Lewy-Bodies, can have a later onset time than AD. A third recommendation is to collect severity and timeline data when observing the incidence of dementia. Since diseases, like depression, can vary drastically in the severity and length, the incidence of dementia may differ based on those parameters. A final recommendation is to include many dementia subtypes when evaluating the incidences of dementia among various disorders. The basis behind this recommendation is how the interactions of different dementia subtypes may differ for a particular illness.

ACKNOWLEDGMENT

The authors thank the authors of the sources included in this systematic review.

REFERENCES

[1] P. Thaipisuttikul, K. Jaikla, S. Satthong, and P. Wisajun, "Rate of conversion from mild cognitive impairment to dementia in a Thai hospital-based population: A retrospective cohort," Alzheimer's & Dementia : Translational Research & Clinical Interventions, vol. 8, no. 1, 2022, doi: 10.1002/trc2.12272.

[2] D.-Y. Song et al., "Jidong cognitive impairment cohort study: Objectives, design, and baseline screening," Neural Regeneration Research, vol. 15, no. 6, pp. 1111–1119, 2020, doi: 10.4103/1673-5374.266070.

[3] F. S. Dafsari and F. Jessen, "Depression—an underrecognized target for prevention of dementia in alzheimer's disease," Translational Psychiatry, vol. 10, no. 1, 2020, doi: 10.1038/s41398-020-0839-1.

[4] I. Lisko, J. Kulmala, M. Annetorp, T. Ngandu, F. Mangialasche, and M. Kivipelto, "How can dementia and disability be prevented in older adults: Where are we today and where are we going?," Journal of Internal Medicine, vol. 289, no. 6, pp. 807–830, 2021, doi: 10.1111/joim.13227.

[5] L. Bonanni et al., "Post traumatic stress disorder heralding the onset of semantic frontotemporal dementia," Journal of Alzheimer's Disease, vol. 63, no. 1, pp. 203–215, 2018, doi: 10.3233/JAD-171134.

[6] T. Matsuoka, Z. Ismail, and J. Narumoto, "Prevalence of Mild Behavioral Impairment and Risk of Dementia in a Psychiatric Outpatient Clinic," Journal of Alzheimer's Disease, vol. 70, no. 2, pp. 503–511, 2019, doi: 10.3233/JAD-190278.

[7] A. X. Lai, A. R. Kaup, K. Yaffe, and A. L. Byers, "High Occurrence of Psychiatric Disorders and Suicidal Behavior Across Dementia Subtypes," The American Journal of Geriatric Psychiatry, vol. 26, no. 12, pp. 1191–1201, Dec. 2018, doi: 10.1016/j.jagp.2018.08.012.

[8] G. L. Dunietz, R. D. Chervin, J. F. Burke, A. S. Conceicao, and T. J. Braley, "Obstructive sleep apnea treatment and dementia risk in older adults," Sleep, vol. 44, no. 9, p. zsab076, Sep. 2021, doi: 10.1093/sleep/zsab076.

[9] K. Radford et al., "Factors Associated with the High Prevalence of Dementia in Older Aboriginal Australians," J Alzheimers Dis, vol. 70, no. s1, pp. S75–S85, 2019, doi: 10.3233/JAD-180573.

[10] S.-M. Wang et al., "Late-life depression, subjective cognitive decline, and their additive risk in incidence of dementia: A nationwide longitudinal study.," PLoS ONE, vol. 16, no. 7, pp. e0254639–e0254639, Jul. 2021, doi: 10.1371/journal.pone.0254639.

[11] C. I. Rosca et al., "Prevalence of Cardio-Embolic Brain Complications in Permanent and Paroxysmal Atrial Fibrillation Patients," Healthcare, vol. 11, no. 2, p. 175, 2023, doi: 10.3390/healthcare11020175.

[12] S. D. Nagar et al., "Investigation of hypertension and type 2 diabetes as risk factors for dementia in the All of Us cohort," Scientific Reports (Nature Publisher Group), vol. 12, no. 1, 2022, doi: 10.1038/s41598-022-23353-z.

[13] A. Kershenbaum et al., "Investigation of risk of dementia diagnosis and death in patients in older people's secondary care mental health services," International Journal of Geriatric Psychiatry, vol. 36, no. 4, pp. 573–582, 2021, doi: 10.1002/gps.5455.

[14] J. Stott et al., "Associations between psychological intervention for anxiety disorders and risk of dementia: a prospective cohort study using national health-care records data in England," Lancet Healthy Longev, vol. 4, no. 1, pp. e12–e22, Jan. 2023, doi: 10.1016/S2666-7568(22)00242-2.

[15] M. Montero-Odasso et al., "SYNERGIC TRIAL (SYNchronizing Exercises, Remedies in Gait and Cognition) a multi-Centre randomized controlled double blind trial to improve gait and cognition in mild cognitive impairment," BMC Geriatr, vol. 18, no. 1, p. 93, Apr. 2018, doi: 10.1186/s12877-018-0782-7.

[16] T. D. van Balkom et al., "Effect of eight-week online cognitive training in Parkinson's disease: A double-blind, randomized, controlled trial," Parkinsonism Relat Disord, vol. 96, pp. 80–87, Mar. 2022, doi: 10.1016/j.parkreldis.2022.02.018.

[17] L. Feng et al., "Effects of choral singing versus health education on cognitive decline and aging: a randomized controlled trial," Aging (Albany NY), vol. 12, no. 24, pp. 24798–24816, Dec. 2020, doi: 10.18632/aging.202374.

[18] C.-H. Huang, M.-C. Lin, I.-C. Chou, and C.-L. Hsieh, "Acupuncture Treatment is Associated with Reduced Dementia Risk in Patients with Migraine: A Propensity-Score–Matched Cohort Study of Real-World Data," Neuropsychiatric Disease and Treatment, vol. 18, pp. 1895–1906, 2022, doi: 10.2147/NDT.S372076.

[19] S.-A. Chu et al., "Acupuncture May Decrease the Incidence of Post-stroke Dementia: A Taiwan Nationwide Retrospective Cohort Study," Frontiers in Neurology, vol. 12, 2021, doi: 10.3389/fneur.2021.657048.

[20] C. Ohlmeier, K.-U. Saum, W. Galetzka, D. Beier, and H. Gothe, "Epidemiology and health care utilization of patients suffering from Huntington's disease in Germany: real world evidence based on German claims data," BMC Neurology, vol. 19, no. 1, pp. 1–8, Dec. 2019, doi: 10.1186/s12883-019-1556-3.

[21] Y.-H. Wu, Y.-H. Chen, M.-H. Chang, and C.-H. Lin, "Depression in Parkinson's disease: A case-control study," PLoS ONE, vol. 13, no. 2, pp. 1–9, 2/1/2018 2018, doi: 10.1371/journal.pone.0192050.

[22] H. Bickel et al., "The Prevalence of Dementia and Cognitive Impairment in Hospitals," Dtsch Arztebl Int, vol. 115, no. 44, pp. 733–740, Nov. 2018, doi: 10.3238/arztebl.2018.0733.

[23] O. Albai, M. Frandes, R. Timar, D. Roman, and B. Timar, "Risk factors for developing dementia in type 2 diabetes mellitus patients with mild cognitive impairment," Neuropsychiatr Dis Treat, vol. 15, pp. 167–175, Jan. 2019, doi: 10.2147/NDT.S189905.

[24] Y.-L. E. Chan et al., "Treatment-Resistant depression enhances risks of dementia and alzheimer's disease: A nationwide longitudinal study," J Affect Disord, vol. 274, pp. 806–812, Sep. 2020, doi: 10.1016/j.jad.2020.05.150.

[25] R. Savica, B. R. Grossardt, W. A. Rocca, and J. H. Bower, "Parkinson disease with and without Dementia: A prevalence study and future projections," Movement Disorders, vol. 33, no. 4, pp. 537–543, 2018, doi: 10.1002/mds.27277.

[26] H. Shimada, T. Doi, S. Lee, H. Makizako, L.-K. Chen, and H. Arai, "Cognitive Frailty Predicts Incident Dementia among Community-Dwelling Older People," Journal of Clinical Medicine, vol. 7, no. 9, Art. no. 9, Sep. 2018, doi: 10.3390/jcm7090250.

[27] Y. J. Jang et al., "Additive interaction of mid- to late-life depression and cerebrovascular disease on the risk of dementia: a nationwide population-based cohort study," Alzheimer's Research & Therapy, vol. 13, no. 1, p. 61, Mar. 2021, doi: 10.1186/s13195-021-00800-z.

[28] J.-Y. Liao, C. T.-C. Lee, T.-Y. Lin, and C.-M. Liu, "Exploring prior diseases associated with incident late-onset Alzheimer's disease dementia.," PLoS ONE, vol. 15, no. 1, pp. e0228172–e0228172, Jan. 2020, doi: 10.1371/journal.pone.0228172.

[29] S.-J. Kim, S. M. Park, H.-J. Cho, and J. W. Park, "Primary headaches increase the risk of dementias: An 8-year nationwide cohort study," PLOS ONE, vol. 17, no. 8, p. e0273220, Aug. 2022, doi: 10.1371/journal.pone.0273220.

[30] D. Valentine et al., "Comorbidity and Cancer Disease Rates among Those at High-Risk for Alzheimer's Disease: A Population Database

Analysis," International Journal of Environmental Research and Public Health, vol. 19, no. 24, p. 16419, 2022, doi: 10.3390/ijerph192416419.

[31] O.-C. Yu et al., "Association between dementia and depression: a retrospective study using the Korean National Health Insurance Service-National Sample Cohort database," BMJ Open, vol. 10, no. 10, p. e034924, 2020, doi: 10.1136/bmjopen-2019-034924.

[32] H. Furby, A. Siadimas, L. Rutten-Jacobs, F. B. Rodrigues, and E. J. Wild, "Natural history and burden of Huntington's disease in the UK: A population-based cohort study," European Journal of Neurology, vol. 29, no. 8, pp. 2249–2257, 2022, doi: 10.1111/ene.15385.

[33] A. Lotfi, C. Langensiepen, and S. Yahaya, "Socially assistive robotics: Robot exercise trainer for older adults," Technologies, vol. 6, no. 1, p. 32, 2018, doi:10.3390/technologies6010032.

[34] F. Yuan, E. Klavon, Z. Liu, R. P. Lopez, and X. Zhao, "A systematic review of robotic rehabilitation for cognitive training," Frontiers in Robotics and AI, vol. 8, 2021.