Health and Aging: Development of The Irish Longitudinal Study on Ageing Health Assessment

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OBJECTIVES: To assist researchers planning studies similar to The Irish Longitudinal Study on Ageing (TILDA), concerning the development of the health assessment component, to promote use of the archived data set, to inform researchers of the methods employed, and to complement the accompanying article on normative values.

DESIGN: Prospective, longitudinal study of older adults.

SETTING: Republic of Ireland.

PARTICIPANTS: Eight thousand five hundred four community-dwelling adults who participated in wave 1 of the TILDA study.

MEASUREMENTS: The main areas of focus for the TILDA health assessments are neurocardiovascular instability, locomotion, and vision.

RESULTS: The article describes the scientific rationale for the choice of assessments and seeks to determine the potential advantages of incorporating novel biomeasures and technologies in population-based studies to advance understanding of aging-related disorders.

CONCLUSION: The detailed description of the physical measures will facilitate cross-national comparative research and put into context the normative values outlined in the subsequent article. **J Am Geriatr Soc 61:S269–S278, 2013.**

Key words: aging; health; biomeasures

The Irish Longitudinal Study on Ageing (TILDA) was designed to provide an evidence base for addressing current and emerging concerns associated with population aging in Ireland. Before the establishment of the study, only minimal national information was available on the prevalence and incidence of disease in the older population for policy development, program planning, and health research. Because one of the study priorities is to provide ongoing, accurate information on the health of Ireland's older population to policy-makers, it was clear from the outset that a detailed assessment of physical health using objective measures was necessary.

The importance of the integration of physical measures and biomarkers into population-based studies of aging is increasingly being recognized.[1] The scientific rationale includes validation of self-reports of health and a richer modeling of pathways of influence between socioeconomic and physical health. In addition, objective measures provide the opportunity to measure undiagnosed disease in ways other than self-report.

The objectives of this article are to aid researchers developing health assessments in similar populations and to inform researchers who are analyzing the TILDA data set of the rationale for the measures selected. This information will advance international harmonization of physical measures in aging studies and will put into context the normative values outlined in the accompanying article.[2]

Because this article primarily addresses the development of the TILDA health assessment, the reader is referred to two other articles to obtain a broader overview of the study. The TILDA cohort article details the overall aims, design, and time frame of the study and the funding sources and summarizes the main themes included in the study.[3] The background to the study, sample design, fieldwork procedures, response rates, and weighting are addressed in the accompanying article, "Design and Methodology of The Irish Longitudinal Study on Aging."

HEALTH RESEARCH DIRECTION

Expert working groups were assembled drawing on the expertise of psychologists, gerontologists, cardiologists, physiotherapists, ophthalmologists, nurses, geneticists, psychiatrists, and biomedical engineers. Clinical domains were prioritized based on relevance to the process of aging, the

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lack of prevalence data and diseases that could reliably be studied in a large sample of adults in a population-based study, and local expertise and policy requirements. Three areas were identified as priorities for aging research: neurocardiovascular instability (NCVI), locomotion, and vision. NCVI is defined as "age-related changes in blood pressure and heart-rate behaviour, manifesting as exaggerated blood pressure variability, hypotension, hypertension, cardiac arrhythmias and autonomic function."[4] NCVI may be a modifiable cause of gait instability, falls, cognitive decline, and visual impairment.[4–6] The causal pathways that link these disorders will be explored in subsequent waves of the study.

STUDY DESIGN AND DATA COLLECTION

The collection of physical measures in a nationwide survey poses many challenges, including the financial, logistical, and ethical considerations associated with collecting biomeasures over a wide geographic area and staffing and training of a field force of research nurses. Other longitudinal studies on aging have used three main models of data collection. Lay interviewers may take basic objective measurements at the time of face-to-face interviews (Health and Retirement Study (HRS) (USA),[7] Survey of Health and Retirement in Europe[8]), a nurse may visit the respondent's home after the original interview (English Longitudinal Study of Ageing (ELSA),[9] Newcastle 85+ Study[10]), or respondents may attend fixed (Rotterdam Study,[11] Cardiovascular Health Study[12]) or mobile (National Health and Nutrition Examination Survey[13]) health centers where medical personnel conduct assessments. Because many of the biomeasures selected for inclusion in TILDA involved the use of complex technologies, fixed health assessment centers were deemed an appropriate model. Based on the geography of Ireland (small country with total area 81,638 km^2) and the population distribution within the country, two centers in areas of maximum population density were chosen (Dublin and Cork). To encourage participation, travel costs to and from centers were provided. For respondents traveling more than 2 hours, overnight accommodation and subsistence was also offered, although from our experience in the first wave, many respondents did not avail of this.

In the first pilot, only center-based assessments were offered to respondents, but there were concerns that individuals who chose to attend an assessment center would differ systematically from those who refused a health assessment or were unable to attend a center. Therefore, in the second pilot, nurse-led home assessments were available to respondents unable or unwilling to attend health centers. Respondents who opted for a home assessment were older and had higher levels of physical disability, weaker grip strength, and slower walking speed than center-based respondents.[14] Therefore, a model of data collection that included in-home and center-based physical assessments was selected for Wave 1 of TILDA to avoid systematic overrepresentation of younger, healthier respondents.

Eight thousand five hundred four respondents were recruited at random across the Republic of Ireland, giving a household response rate of 62%; 8,175 of these were aged 50 and older. All respondents completed a computer-assisted personal interview in their own home covering economic, social, and health aspects of their lives.[3] Of the 8,504 respondents interviewed, 7,262 (85.4%) initially agreed to a health assessment, 210 (2.5%) were undecided, and 1,032 (12.1%) refused; 16.3% of respondents who agreed to a center assessment (n = 1,033) and 12.8% who agreed to a home assessment (n = 128) ultimately did not complete an assessment. In total, 6,150 respondents (72.3%) completed a health assessment, of whom 5,275 (85.8%) opted for a center-based assessment and 875 (14.2%) for a home assessment. (See Appendices A and B for further details.) Almost all respondents (99.8%) who underwent a health assessment consented to providing a venous blood sample. Table 1 details the sociodemographic and health characteristics of the cohort overall and according to type of health assessment.

Table 2 summarizes the health characteristics of the health center and home assessment cohorts, as well as the total sample that underwent any assessment. Consistent

Table 1. Sociodemographic, Behavioral, and Physical Health Characteristics of Participants in The Irish Longitudinal Study on Ageing Health According to Type of Health Assessment

Characteristic	No Assessment, n = 2,354	Health Center, n = 5,275	Home Assessment, n = 875	Total Computer-Assisted Personal Interview, n = 8,504
Sociodemographic				
Age, mean ± standard deviation	66.0 ± 10.9	61.7 ± 8.4	70.6 ± 11.3	64.0 ± 10.0
Male, n (%)	1,043 (44.4)	2,337 (44.3)	400 (45.7)	3,780 (44.4)
Private medical insurance, n (%)	1,027 (43.7)	3,575 (67.8)	305 (34.8)	4,907 (57.7)
Married, n (%)	1,454 (61.8)	4,066 (77.1)	446 (50.9)	5,966 (70.2)
Highest education achieved tertiary, n (%)	496 (21.1)	1,942 (36.8)	110 (12.6)	2,548 (30.0)
Living in a county with a health center (Dublin or Cork), n (%)	721 (30.7)	2,143 (40.6)	112 (12.8)	2,976 (35.0)
Physical and behavioral health, n (%)				
Self-rated health excellent, very good, or good	1,142 (48.7)	2,145 (40.7)	532 (61.0)	3,819 (45.0)
Reporting ≥2 ADL or instrumental ADL disabilities	174 (7.4)	186 (3.5)	133 (15.2)	493 (5.8)
Physical activity level (low)	842 (36.3)	1,456 (27.8)	384 (44.2)	2,682 (31.8)
Smoker (current)	570 (24.3)	804 (15.2)	190 (21.7)	1,564 (18.4)

ADL = activity of daily living.

Table 2. Objective Physical and Cognitive Health Measures by Type of Health Assessment (Center vs Home)

Health Measure	Health Center Cohort, n = 5,275	Home Assessment Cohort, n = 875	Combined, N = 6,150
	Median (Interquartile Range)		
Cardiovascular			
Total cholesterol, mmol/L	5.1 (4.5–5.8)	4.9 (4.1–5.6)	5.1 (4.4–5.8)
Systolic blood pressure, mmHg	132.5 (120–146.5)	139.0 (126.0–155.5)	133.5 (121.0–147.5)
Diastolic blood pressure, mmHg	81.5 (74.5–89.0)	82.0 (74.0–90.5)	82.0 (74.5–89.5)
Body mass index, kg/m^2	28.0 (25.2–31.2)	28.7 (25.5–32.3)	28.1 (25.2–31.4)
Cognition			
Mini-Mental State Examination	29.0 (28.0–30.0)	27.0 (25.0–29.0)	29.0 (28.0–30.0)
Montreal Cognitive Assessment	26.0 (23.0–28.0)	23.0 (19.0–25.0)	25.0 (23.0–27.0)
Mobility: Timed Up-and-Go Test, seconds	8.3 (7.3–9.4)	10.5 (8.7–13.5)	8.4 (7.4–9.8)
Strength: Grip strength, kg	24.5 (19.0–33.0)	23.0 (17.0–30.0)	24.0 (19.0–32.5)

with the findings from the national pilot,[14] respondents who opted for a home assessment in Wave 1 had lower levels of global cognitive function, walked slower, and had weaker handgrip strength than those who opted for a center-based assessment.

Table 3 shows the association between population characteristics and whether the participant chose to attend a health center or to have their health assessment conducted at home. Respondents who chose a home assessment rather than a health center assessment were more likely to be older, have lower levels of education, report a disability, rate their health as poor, and be a current smoker.

Participation rates in the health assessment component of the study were similar for respondents living in urban (Dublin or another town or city, 74.3%) and rural areas (70.3%). Although the overwhelming preference for both populations was a center-based assessment, 13.0% of respondents from a rural area opted for a home assessment, versus 7.8% of those from an urban area. Respondents from a rural area made up 60.6% of home assessments and 44.5% of center assessments. Proximity to a center was an important factor, with respondents who lived in an area with a center (Cork or Dublin) almost twice as likely to complete a center based assessment as those who lived in an area without a center (odds

Table 3. Association Between Population Characteristics and Attendance at a Home or Health Center Assessment

Characteristic	Underwent a Home Assessment	Underwent a Health Center Assessment	Underwent Home or Center Assessment
	Odds Ratio (95% Confidence Interval)		
Age (reference 50–64)			
<50	0.93 (0.53–1.64)	0.97 (0.74–1.26)	0.99 (0.75–1.31)
65–74	1.67 (1.35–2.05)[a]	0.82 (0.73–0.92)[b]	0.93 (0.83–1.06)
≥75	6.46 (5.12–8.14)[a]	0.32 (0.27–0.37)[a]	0.63 (0.55–0.73)[a]
Female versus male	0.92 (0.77–1.10)	1.03 (0.93–1.14)	1.01 (0.91–1.12)
Education (reference third level)			
Primary	3.04 (2.34–3.95)[a]	0.48 (0.42–0.55)[a]	0.60 (0.52–0.70)[a]
Secondary	1.97 (1.53–2.52)[a]	0.73 (0.64–0.83)[a]	0.82 (0.72–0.94)[b]
Same county as center	0.17 (0.13–0.21)[a]	1.97 (1.77–2.19)[a]	1.22 (1.10–1.36)[a]
Single, widowed, divorced	2.17 (1.81–2.60)[a]	0.62 (0.55–0.69)[a]	0.76 (0.68–0.85)[a]
Disabled	1.93 (1.40–2.65)[a]	0.72 (0.57–0.90)[b]	1.13 (0.90–1.41)
Private health insurance	0.47 (0.39–0.57)[a]	1.86 (1.67–2.07)[a]	1.63 (1.46–1.82)[a]
Poor self-rated health	1.67 (1.40–2.00)[a]	0.85 (0.77–0.95)[b]	1.00 (0.90–1.11)
Physical activity (reference low)			
Moderate	0.77 (0.62–0.95)[c]	1.19 (1.05–1.35)[b]	1.12 (0.99–1.27)
High	0.75 (0.60–0.93)[b]	1.22 (1.07–1.38)[b]	1.15 (1.01–1.31)[c]
Smoking (reference never)			
Previous	0.93 (0.76–1.13)	1.05 (0.94–1.18)	1.06 (0.95–1.19)
Current	1.42 (1.12–1.81)[b]	0.64 (0.56–0.74)[a]	0.68 (0.59–0.78)[a]
Depression (reference none)			
Subthreshold	0.90 (0.72–1.12)	1.18 (1.03–1.35)[c]	1.17 (1.02–1.34)[c]
Clinically significant	0.89 (0.66–1.18)	1.09 (0.92–1.29)	1.05 (0.88–1.25)

Excluding the "Characteristic" column, Column 1 shows the effects of population characteristics on whether the participant chose to attend a health center or to have their health assessment conducted at home. Columns 2 and 3 show the determinants of having any health assessment, before and after the home assessments are included. Therefore, Column 2 shows the effects of population characteristics on participation in the health assessment before the home assessment was offered and Column 3 shows the effect of each characteristic after the home assessment was offered. [a] $p < .001$; [b] $p < .01$; [c] $p < .05$.

ratio = 1.97, 95% confidence interval = 1.77–2.19). From a cost perspective, there was only a marginal difference between home and center assessments, with each home assessment costing approximately 85% of a health center assessment.

PHYSICAL AND COGNITIVE MEASURES

Table 4 details the full list of TILDA physical and cognitive measures for the home- and center-based assessments. Although many of these measures will be discussed in more detail later, a comprehensive description of the protocols used is beyond the remit of this article. Detailed standard operating procedures for each test are available at www.tilda.ie. A center-based assessment took approximately 3 hours to complete and a home assessment approximately 1 hour and 10 minutes. Respondents received information on height, weight, seated blood pressure, and lipid values from the health assessment. Respondents who attended a health center were also given information on heel ultrasound and visual acuity. Further information on TILDA is available in the design report, which is available on www.tilda.ie.[15]

Complex, and in some instances novel, technologies were adopted where appropriate to provide more in-depth physiological information. These included the use of an instrument (Finometer, Finapres Measurement Systems, Arnhem, the Netherlands) that measures blood pressure noninvasively on a beat-to-beat basis, producing similar information to intra-arterial blood pressure recordings, and a walkway system (GAITrite, CIR Systems, Inc., Havertown, PA) to assess spatial and temporal gait parameters. The use of novel technologies in population-based aging research can potentially generate new insights into the causal pathways underlying the aging process and detect early biomarkers of physical and cognitive decline. Technologies that will evolve based on TILDA research are being developed to provide mobile, easily applied systems suitable for home deployment.

COGNITION

At a population level, most cognitive abilities tend to decline with advancing age.[16,17] Physical health factors may mediate differences in the rate of decline of specific cognitive functions between individuals. Maintaining cognitive abilities is of primary importance because cognitive decline can threaten the independence and quality of life of older adults and present challenges to the healthcare system.[18] In a recent review of longitudinal aging studies, one of the information gaps identified for future longitudinal aging studies to address was how mild cognitive impairment could affect healthcare use and health outcomes (e.g., hospitalization) or alter roles (e.g., work, marriage).[19] A comprehensive cognitive assessment was specifically chosen to allow adults with mild cognitive impairment (MCI) to be identified so that it will be possible to address these specific information gaps.

In TILDA, a range of cognitive abilities was assessed using a combination of traditional pen-and-paper and computerized tests. All cognitive testing was conducted in a quiet room and in a fixed order.

Global cognition was assessed using the Mini-Mental State Examination (MMSE)[20] and the Montreal Cognitive

Table 4. Details of Physical Measures and Equipment Used in The Irish Longitudinal Study on Ageing Health Assessments (Home and Center)

Variable	Center	Home	Measurement	Equipment or Test Used
Height	Yes	Yes	1	Wall-mounted measuring rod
Weight	Yes	Yes	1	Electronic floor scale
Waist size[a]	Yes	Yes	2	Standard tape measure
Hip size[a]	Yes	Yes	2	Standard tape measure
Blood pressure	Yes	Yes	3 (2 seated, 1 standing)	Digital automatic blood pressure monitor
Grip strength	Yes	Yes	2 on each hand	Hydraulic hand dynamometer
Global cognition	Yes	Yes	1	
Attention	Yes	Yes	1	Sustained Attention Response Time
Visual memory	Yes	Yes	1	CAMDEX Picture Memory Test
Speed of processing	Yes	Yes	1	Choice reaction time test
Executive function	Yes	Yes	1	Timed Colour Trails 1 & 2 Visual reasoning—CAMDEX
Timed Up-and-Go	Yes	Yes	1	Standard tape measure, chair, tape
Phasic blood pressure	Yes	No	1	Noninvasive beat-to-beat blood pressure monitor
Pulse wave velocity	Yes	No	2	Noninvasive pulse wave velocity monitor
Heart rate variability	Yes	No	1 (10-minute recording)	Holter recorder
Visual acuity	Yes	No	2 (left and right eye separately)	Logmar chart
Contrast sensitivity	Yes	No	2 (best eye, low light ± glare)	Functional visual analyzer
Retinal photograph	Yes	No	2 (left and right eye)	Nonmydriatic automatic camera
Macular pigment optical density	Yes	No	12	Densitometer
Bone density	Yes	No	1 (nondominant foot)	Ultrasound machine
Computerized assessment of gait	Yes	No	3 walks, 2 under dual task	Sensored mat
Venous blood sample	Yes	Yes	25 mL	Standard blood taking materials

CAMDEX = Cambridge Examination for Mental Disorders of the Elderly.

[a]If the difference between two measurements was >3 cm, a third measurement was required, with the values for the last two measurements recorded.

Assessment.[21] Although the MMSE is a widely used screening tool, it lacks assessment of some domains (e.g., executive function) and is insensitive to MCI and early dementia, especially in older adults with high intelligence and educational attainment.[22–24] The Montreal Cognitive Assessment is a more-recent screening test, with more-extensive memory and executive function assessment than the MMSE and may be more useful in monitoring transition to MCI and early dementia.

Sustained attention is the ability to direct and focus cognitive activity on specific stimuli and is necessary for completion of cognitively planned activity, sequenced action, and thought. When faced with a boring and repetitive task, attention levels tend to fluctuate and become more variable. Although standard written tests capture some elements of attention, a computer-based test is more sensitive to variability over time. The Sustained Attention to Response Test, a computer-based test designed by neuroscience researchers at Trinity College Dublin and widely used internationally, was selected for TILDA.[25,26]

Visual memory involves the ability to store and retrieve previously experienced visual sensations and perceptions when the stimuli that originally evoked them are no longer present. Changes in immediate visual memory performance have long-term prognostic significance for dementia.[27] The Picture Memory test from the Cambridge Examination for Mental Disorders of the Elderly, Revised (CAMDEX-R) is a short paper-based test of visual memory that is easy to administer.

Choice reaction time (CRT), or speed of processing, is a sensitive predictor of cognitive decline.[28] There are two components of reaction time—the time it takes to plan the move (decision time) and the time it takes to make the move (motor time). Traditional measures of CRT (e.g., letter cancellation test) are pen-and-paper based, with older adults taking considerably longer to complete tasks than younger adults, but these tests are unable to distinguish whether the increase in CRT is due to longer motor time or longer decision time. A computer-based CRT test designed to measure motor and decision times separately was developed in-house for TILDA using a commercially available software package (E-Prime, Psychology Software Tools, Inc., Pittsburgh, PA).

Executive function is the cognitive process that regulates an individual's ability to organize thoughts and activities, prioritize tasks, manage time efficiently, and make decisions. The Colored Trails Test and the Visual Reasoning Test (CAMDEX-R) were chosen for TILDA because they are quick, easy-to-administer paper-based tests that are unambiguous to score.

CARDIOVASCULAR FUNCTION

Elevated systolic (SBP) and diastolic (DBP) blood pressures are important risk factors for cardiovascular diseases such as angina pectoris, myocardial infarction, and stroke. The World Health Organization recognizes hypertension as one of the most important preventable causes of premature morbidity and mortality in developed and developing countries. Orthostatic hypotension is an important cause of unexplained falls and syncope[29] and is associated with significant morbidity[30] and mortality in older adults.[31,32] In TILDA, blood pressure was measured using a digital automated oscillometric blood pressure monitor (2 readings seated and 1 standing) (Omron M10-IT, Omron Inc., Kyoto, Japan). Dynamic beat-to-beat blood pressure was measured using digital artery photoplethysmography (Finometer, Finapres Measurement Systems), which allows for detailed assessment of resting and orthostatic blood pressure behavior in addition to measures of baroreflex sensitivity when analyzed in conjunction with heart rate.

Pulse wave velocity (PWV) is an indicator of arterial stiffness and is a surrogate marker for atherosclerosis. Higher arterial PWV is associated with total mortality and cardiovascular mortality.[33] Two repeated measures of PWV (carotid and femoral) were made (Vicorder system, Skidmore Medical Ltd, Bristol, UK).

Heart rate variability (HRV) (variation in beat-to-beat R-R interval) is a powerful measure of autonomic nervous system function. Low HRV is an independent predictor of mortality after myocardial infarction.[34,35] HRV parameters were derived from electrocardiographic signals measured using a high-sampling-rate (4,000 Hz) Holter monitor (Medilog AR12, Hunt Leigh Healthcare, Woking, UK) with dedicated software (Medilog Darwin, Hunt Leigh Healthcare). Two concerns that arose with HRV measurement were the optimal length of the recording and the influence of respiration. Whereas the Whitehall II study[36] and the Cardiovascular Health Study[12] used 5-minute recordings of HRV, other studies, including the Framingham Heart Study,[37] used longer periods (up to 2 hours). Similarly paced and unpaced breathing have been used in different studies.[38] Following pilot studies, HRV was recorded over 10 minutes—the first 5 minutes at the respondents own breathing rate and the second 5 minutes at a paced breathing rate of 12 breaths per minute.

GAIT

Gait speed is associated with survival in older adults[39] and reflects general health and functional status. The Timed Up-and-Go Test (TUG) and walking speed test are used in aging studies as basic tests of functional mobility. TUG measures, in seconds, the time a respondent takes to stand up from a standard chair, walk 3 m at their usual pace, turn, walk back to the chair, and sit down again.[40] The walking speed test measures the time taken for a respondent to walk a predetermined distance from a standing still start. TUG was selected for TILDA because it assesses proximal muscle strength (standing up from chair), balance (turning), and executive function (following the five-stage command) in addition to gait speed. A chair with armrests and seat height of 46 cm was used in the health center; an available chair that matched these dimensions as closely as possible (seat height 40–50 cm) was used in the home assessment.

Gait patterns change with age, and greater gait variability is predictive of future falls.[41] Older adults have a lower step frequency (fewer steps), shorter stride length (shorter steps), and greater step widths (wider stance). An electronic walkway system is needed to capture the spatial and temporal parameters of gait. A portable walkway system was chosen for use in TILDA. The length of the walkway was 4.88 m, with 2.5 m allowed for acceleration and

2 m for deceleration.[42] Footfalls were recorded on the walkway according to the location of activation and deactivation of the sensors as a function of time. Application software calculated spatiotemporal parameters for all foot contacts on the mat.[43] The use of assistive walking aids, including walking sticks, was allowed. Respondents completed three walks: one under single-task conditions (walk only) and two under dual-task conditions (walk plus cognitive task and walk plus manual task). For the single task, respondents were asked to walk along the mat at their usual pace. For the cognitive dual task, respondents were instructed to walk at their usual pace across the mat reciting alternate letters of the alphabet. The manual dual task involved respondents completing the same walk while carrying a glass of water. No prioritization of either task was given for the dual-task walks.

VISION

Decline in visual acuity is associated with cognitive decline and falls.[44,45] Visual acuity in each eye was assessed separately using wall-mounted LOGMar charts.

Contrast sensitivity is the ability to see objects that may not be outlined clearly or that do not stand out from their background. Poor contrast sensitivity is associated with falls.[45] In the pilot studies, contrast sensitivity was assessed using Pelli-Robson charts. Standardization of luminescence was not possible in both health centers using these charts, so a visual analyser (Functional Visual Analyser, Stereo Optical Company, Inc., Chicago, IL) was used in the first wave in lieu of the charts because it is internally illuminated, and test responses are therefore independent of environmental light.

Age-related macular degeneration (AMD) is a degenerative condition and the leading cause of adult-onset blindness in the developed world. The pathogenesis of AMD is uncertain, although there is a growing body of evidence that low levels of macular pigment lead to a greater risk of developing AMD. Greater dietary intake of specific carotenoids (lutein and zeaxanthin) leads to higher macular pigment levels, raising the possibility that appropriate dietary supplementation or modification could confer protection against development or progression of AMD.[46] Macular pigment optical density is a valid measure of macular pigment and was measured using the densitometer by (Macular Metrics Densitometer, HFP, Providence, RI).[47]

Fundus photography involves the use of a retinal camera to photograph the regions of the vitreous, retina, choroid, and optic nerve. Given the research focus on AMD and on atherosclerosis in TILDA, digital fundus photography (Nidek AFC-210 Non-Mydriatic Auto Fundus Camera, Nidek, Gamagori, Japan) was conducted on each eye using undilated pupils.

BONE AND MUSCLE STRENGTH AND ANTHROPOMETRICS

The prevalence of osteoporosis increases with advancing age,[48] and it is estimated that 40% to 50% of women and 25% of men aged 50 and older will experience an osteoporosis-related fracture during their lifetime.[49] Although dual energy X-ray absorptiometry scan is the current criterion standard system for diagnosing osteoporosis, these machines are expensive and large and expose the individual to ionizing radiation, so they were not feasible for use in TILDA. Quantitative ultrasound (QUS) of the os calcis is an effective, low-cost method of assessing bone strength and osteoporotic fracture risk. Although it cannot be used on its own to diagnose osteoporosis, low bone strength on QUS is predictive of hip fracture in older women.[50] Each respondent underwent a single heel bone ultrasonometry measurement (Achilles Insight, GE Medical systems, Milwaukee, WI) of their nondominant foot.

Low handgrip strength is consistently associated with premature mortality, disability, and other health-related complications in middle-aged and older people.[51] Handgrip strength was assessed using a gripping handle with a strain-gauge and an analogue reading scale (Baseline dynamometer, Fabrication Enterprises, Inc., Irvington, NY). Two measures were taken per hand, alternating the nondominant and dominant hands.

Height and weight were measured using standard techniques and used to calculate body mass index. Given the increasing interest in the distribution of body fat as an important indicator of risk of cardiovascular disease, waist-to-hip ratio was also measured.

CHALLENGES FACED

Technology Issues

One concern at the study development stage was that the novel technologies could prove difficult to use or be met with resistance from respondents, but these concerns did not materialize in Wave 1, and feedback indicated that the respondents enjoyed these novel technologies and computerized tests. Although participants with cognitive impairment were not recruited at baseline in TILDA, in anticipation that some of the participants would not have used a computer before and that many participants would experience cognitive decline over the course of the study, the computer cognitive tests selected for use were simple and easy to use and where possible used modified keyboards. All participants were given a supervised practice before the main test to ensure that they understood the instructions and were comfortable taking the test. Three main factors contributed to the successful introduction of novel technologies in TILDA: the comprehensive small-group training of research nurses, with plenty of hands-on experience (including practice on volunteers); the detailed step-by-step protocol manuals with clear, straightforward instructions for the participants; and the availability of a biomedical engineer to develop and implement an equipment management standard operating procedure, including troubleshooting any technical problems as they arose.

Residential addresses in Ireland do not have a specific postal code, with some addresses simply referring to a general geographic area (referring to a general area rather than a precise address), so there was some concern that the home nurses would have difficulty locating the TILDA respondents. To address this concern, each nurse was equipped with a GPS prepopulated with the individual addresses. Feedback from the nurses indicated that this was successful.

IT Issues

The extraction of core variables from some of the more-complex tests (walkway system, computerized cognitive tests) presented specific challenges. These tests generate individual files for each respondent that require further processing to determine the variables of interest. If the raw file was simply attached to each respondent's unique TILDA identifier, any researcher interested in this area would need to download and interrogate each individual file, which would be time-consuming and duplicative. To overcome this, software was developed so that all important variables would be extracted automatically at the time of the assessment and that these variables, together with the raw files, would be uploaded and stored on a secure central server. This was done using USB keys in the center and handheld personal digital assistant devices in the home assessments.

COLLECTION OF BLOOD SAMPLES

Determining how best to collect venous blood samples from the TILDA respondents provided many challenges, most of which have been detailed extensively elsewhere.[15] A number of important principles informed development of the strategy for blood collection in TILDA. The aim was to collect samples that would facilitate the analyses of measures currently known to be of interest for describing and studying aging while also allowing the widest possible range of assays that could plausibly be envisaged for the future. Venous blood samples were collected at home and center health assessments, and all samples were transported in temperature-controlled boxes to a central laboratory for processing and aliquoting within 48 hours. A dedicated courier collected the samples from each center at 6:00 p.m. every evening (Monday to Saturday). For home-based assessments, nurses brought the blood samples to one of 40 dedicated dropoff points across the country. Because the couriers collected from these dropoff points in the afternoon, home assessments in rural areas could not be conducted on Friday evenings or on weekends at short notice, but with 2 to 3 days notice of an assessment, it was possible to arrange a dedicated courier collection.

TILDA respondents were not requested to fast, given the additional complexity of coupling fasting with travel. Respondents consented separately for blood samples for immediate analysis, for future analysis (storage up to 20 years), and for the extraction and storage of DNA.

CONCLUSION

In summary, this article describes the complex scientific and methodological processes involved in the development and implementation of the health assessment component of TILDA. It explains the scientific rationale behind the research focus (NCVI, locomotion, vision) and illustrates how the use of novel technologies made study of these areas feasible in a large population-based study of aging. The detailed description of the physical measures chosen for TILDA could play an important role in promoting data harmonization across aging studies. Together with the article on normative values,[2] this article will provide practical information for the application of popular tests in comprehensive geriatric assessments.

TILDA aims to improve the health of older Irish people by accelerating understanding of the aging process. This is a challenging task that involves multidisciplinary collaborations between clinicians, epidemiologists, biologists, statisticians, and biomedical engineers. TILDA provides the infrastructure to implement novel approaches and technologies in aging research and bridge the gap between observational studies and biomedical research. Drawing on this infrastructure, scientists will generate new knowledge that will allow the pressing social and economic issues facing society as a result of population aging to be more intelligently addressed.

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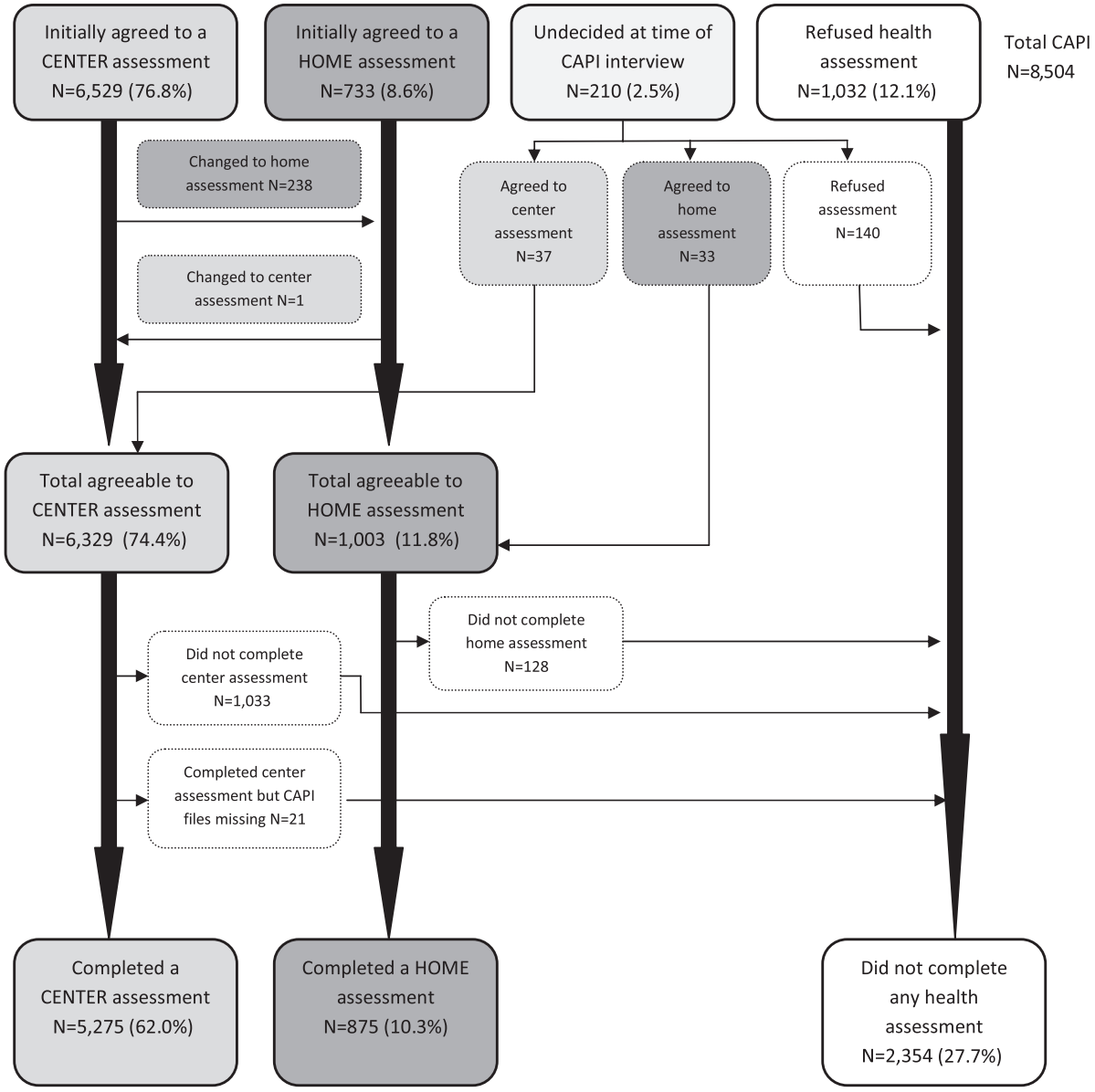
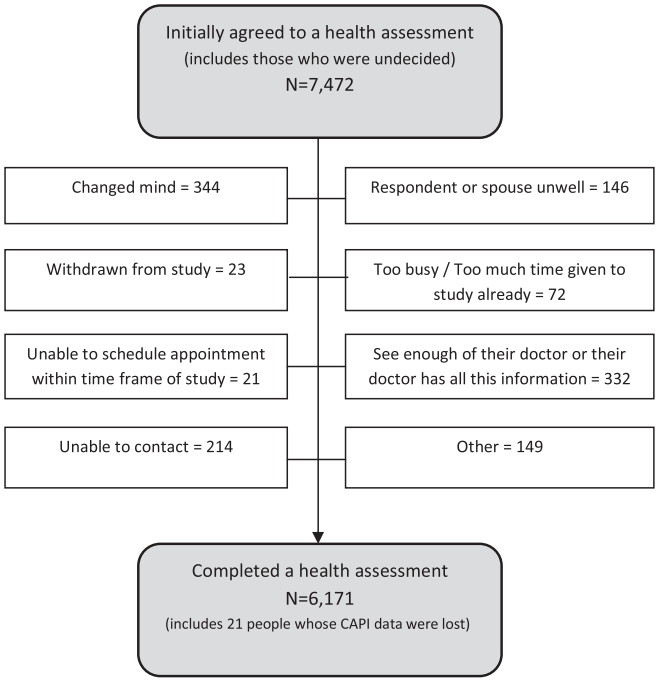
APPENDIX A: UPTAKE OF A HEALTH ASSESSMENT IN THE FIRST WAVE OF THE IRISH LONGITUDINAL STUDY ON AGEING HEALTH. CAPI = COMPUTER-ASSISTED PERSONAL INTERVIEW



APPENDIX B: REASONS WHY RESPONDENTS WHO AGREED TO A HEALTH ASSESSMENT DID NOT COMPLETE ONE