San Francisco July 25, 2016

Designing a Prototype Atlas of Caregiving

Hugh Dubberly Dubberly Design Office

In 2015, Robert Wood Johnson Foundation funded a pilot study to look at new ways of measuring family caregiving.

Robert Wood Johnson Foundation

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The study produced a report delivered as a PDF and website. The report includes protocols, ethnographies, and visualizations.







Diagram Development The Process of Developing 237 Diagrams





Website









This presentation describes the project:

1 Need: Why study caregiving? 2 Approach: How was the study organized? **3 Measurements:** What data was collected? 4 Visualizations: How was the data processed? **5 Results:** What did we learn?

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PART ONE

Need: Why study caregiving?

We rely on healthcare professionals (HCPs) to help us maintain our health—typically in hospitals and clinics.



Yet many have chronic health conditions, which require self-management and the help of family caregivers, working at home around the clock.



'As of 2012, about half of all adults [in the U.S.]—117 million people had one or more chronic health conditions.'



— Centers for Disease Control and Prevention (CDC)

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2.4m

Stroke

Some people have more than one condition.

Chronic conditions require ongoing support, often from family. Experts differ on the number of family caregivers—but it is large.

The U.S. population is ~322,000,000. $\sim 80\%$ are adults = $\sim 257,000,000$. ~39% are caregivers = ~100,000,000*

Source: Pew Research http://www.pewinternet.org/2013/06/20/family-caregivers-are-wired-for-health/

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Calculating the economic value (not even the social value) of family caregiving is difficult but even the most conservative estimates are huge.

If each caregiver spends just 8 hours per week providing care, that's 8 hours / week × 52 weeks / year / caregiver = 416 hours / year / caregiver.

If providing care is worth a minimum wage of \$10 / hour, that's \$10 / hour × 416 hours / year / caregiver = \$4,160 / year / caregiver.

With ~100,000,000 caregivers that's ~\$416,000,000,000 in unpaid labor—almost half a trillion dollars.

Traditional healthcare spending is about 3 trillion per year.

Arguably family caregiving is worth more than \$10 / hour and requires more than 8 hours / week.

At \$15 / hour and 40 hours / week, the hidden economic value of family caregiving approaches the economic value of the healthcare industry.







Family Caregiving



Unfortunately, family caregiving is often overlookedand rarely studied—in part because it's difficult to measure.

Atlas is a metaphor for comprehensive survey and visualization. e.g., Stewart Brand's *The California Water Atlas* (1979).





Traditional healthcare has a number of atlases.



Atlas of Health and Climate

World Health Organization







The Dartmouth Atlas of Health Care

The Center for the Evaluative Clinical Sciences Durtmouth Medical School

The Dartmouth Atlas of Health Care Dartmouth Medical School



Gray's Anatomy

Henry Gray

A number of efforts are underway to map body systems.



Brain function

Cell signaling pathways

Genomics

Proteomics

We set out to collect measurements and make an atlas of caregiving, or at least a prototype.

Study Report

Diagram Development The Process of Developing 237 Diagrams

Study Report posted at http://atlasofcaregiving.com/wp-content/uploads/2016/03/Study Report.pdf

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17

PART TWO

Approach: How was the study organized?

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The key idea was to learn: How might IoT sensors augment traditional ethnography in learning about family caregiving?

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We looked at 14 households

Fernando's household

Ida's household

Teddy's household

Omar's household

20

With 20 participants

Teddy's household

Omar's household

Including over 21 chronic illnesses

birth. She devotes several hours a day to care for her own condition. She also cares for her teenage son Albert, who has depression.

for her mother Debby (80s) who requires 24x7 care for **dementia**. Additional support comes from a paid home aide and other family members. Only-child Fay (30s) cares for her mother Josephine (70s) who has Alzheimer's. With no one to help her, she has put PhD studies on hold to provide 24x7 care.

Gabrielle (60s) is the primary caregiver of her mother Karen (101), who has Alzheimer's. Gabrielle also has health issues of her own and the sleepless nights and caregiving needs of her mother have taken a toll.

Hanna and husband Gaston care for her brother Harvey, who has epilepsy and pneumonia/sepsis. Gaston also cares for his mother, while managing his own chronic pain and edema. Both Hanna and Gaston also work.

Fernando and his wife Laura (50s) are the primary caregivers for Fernando's mother Maria (80s) who has Alzheimer's disease as well as other health conditions. Together, Fernando and Laura have built a care network to support Maria.

Jerry and two teenage sons, Larry and Karl. Karl has Type 1 Diabetes. Nadine is his primary caregiver.

for each other. Patty has **multiple** sclerosis (MS) and Nate has glioblastoma, a terminal condition.

who has behavioral and emotional difficulties stemming from **XYY** Chromosome Disorder.

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Fernando's household

Ida's household

Ida (70s) cares for her husband Ian (70s) who has Lewy Body Dementia and **Dysautonomia**. They moved to San Francisco to be nearer to their children two years ago.

Teddy's household

Teddy (40s) and his wife are the primary caregivers for their two young sons, Van and Walter. Van has Aspergers (ADHD type) as well as encopresis, and Walter has cyclical vomiting syndrome.

Omar's household

Omar (40s) and his separated wife Cindy (40s) share a home with their young son Bob, who has Aspergers.

Using 12 sensors

Measuring 16 factors

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Humidity Temperature

Barometric pressure CO2 Noise

NUISe

Indoor unit

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netatmo

Netatmo Indoor Weather Station

Humidity Temperature

Outdoor unit

- •
- •
- •
- •

Netatmo Outdoor Weather Station

Over an average of 24 hours

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Total length

Study Sleep

Resulting in 5 GB of data—just from the watch.

The BVP sensor is running at 64 Hz. That means it makes a reading every 1/64th of a second. 60 seconds comprise a minute; 60 minutes comprise an hour; and 36 hours is the maximum duration of one of our study sessions.

In other words, one study session comprises 2,160 minutes, and just one of the sensors is collecting 3,840 samples per minute.

That's 8,294,400 samples collected over the course of one 36-hour session.

8,294,000 4,147,200 4,147,200 4,147,200 518,000 518,000 21,772,800

×19

samples for BVP (at 64 Hz) samples for X axis acceleration (at 32 Hz) samples for Y axis acceleration (at 32 Hz) samples for Z axis acceleration (at 32 Hz) samples for EDA (at 4 Hz) samples for skin temperature (at 4 Hz)

samples of raw data for one participant

participants

413,683,200

or nearly half a billion data points

Here's just 1 second—64 rows—of data from the watch.

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Here's just 1 second—64 rows—of data from the watch. BVP is measured at 64 Hz so there's data in every row.

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	1 09:50:47	74.14			-12	16	59
U3:201:41 82./1	09:50:47	85.71		60	!	2	;

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Here's just 1 second—64 rows—of data from the watch. EDA is measured at 4 Hz so there's data in every 15 rows.

Date & Time	BVP	EDA	HR		>	N	moving AVG ACC
2015-08-31 09:50:47	0	0		12	16	60	
2015-08-31 09:50:47				ç	9	00	
2015-08-31 09:50:47				4	0	2	
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2015-08-31 09:50:47	0						
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2015-08-31 09:50:47	0.66			<u>0</u>	ι <u>Ω</u>	60	
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2015-08-31 09:50:47	1.37			2	ι <u>ρ</u>	09	
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2015-08-31 09:50:47	4.42						
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2015-08-31 09:50:47	11.04						
2015-08-31 09:50:47	11.88		,	2	<u>10</u>	09	
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2015-08-31 09:50:47	17.91			2	16	60	
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Here's just 1 second—64 rows—of data from the watch. Heart Rate is measured at 1 Hz so there's data in every 64 rows.

Date & Time	BVP	EDA	Ħ	X	>	N	moving AVG ACC
2015-08-31 09:50:47	0	0		N .	2	0.0	
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2015-08-31 09:50:47	0				16	60	
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2015-08-31 09:50:47	0.01			-10	10	61	
2015-08-31 09:50:47	0						
2015-08-31 09:50:47	-0.03			12	10	60	
2015-08-31 09:50:47	-0.05						
2015-08-31 09:50:47 2015-08-31 09:50:47	-0.05	0.836457		4	10	6	
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2015-08-31 09:50:47	0.36			2	2	3	
2015-08-31 09:50:47	0.66			- 1	ų.	60	
2015-08-31 09:50:47	1.01						
2015-08-31 09:50:47	1.37			-12	10	60	
2015-08-31 09:50:47	1.72						
2015-08-31 09:50:47	2.06			-10	<u>10</u>	61	
2015-08-31 09:50:47	2.4			4	0		
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2015-08-31 09:50:47	4.42						
2015-08-31 09:50:47	5.06			-12	10	60	
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2015-08-31 09:50:47	6.2	1.18386		12	40	60	
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2015-08-31 09:50:47	7.15				4	61	
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2015-08-31 09:50:47	11.04			-	2	3	
2015-08-31 09:50:47	11.88			12	4	09	
2015-08-31 09:50:47	12.56						
2015-08-31 09:50:47	13.14			$\frac{\overline{\gamma_{-}}}{\gamma_{-}}$	10	60	
2015-08-31 09:50:47	13.76						
2015-08-31 09:50:47	14.65			$\frac{1}{\frac{1}{2}}$	16	60	
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2015-08-31 09:50:47	20.32			4	2	3	
2015-08-31 09:50:47	22.9	1.622013		0	- 10	09	
2015-08-31 09:50:47	25.38						
2015-08-31 09:50:47	27.58			$\frac{1}{1}$	ų.	61	
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2015-08-31 09:50:47	42.54				2	3	
2015-08-31 09:50:47	48.15				-10	60	
2015-08-31 09:50:47	54.1						
2015-08-31 09:50:47	59.83				10	60	
2015-08-31 09:50:47	64.97						
2015-08-31 09:50:47	69.58			<u>0</u>	4	б С	
2015-08-31 09:50:47	79.34			-12	9	00	
2015-08-31 09:50:47	85.71		60			/	

:00

Even more data was collected from the environment and motion sensors.

589	average samples from
4,176	average samples from
4,765	average samples of ra
×8	participants (not all house
38,120	data points for enviro

- n environment
- n motion

aw data for one participant

eholds opted-in for instrumentation)

nment and motion

PART THREE

Measurements: What data was collected?

We compiled all the data visualizations into their own document so they could be shown at full size.

Study Report

Data Visualizations

Diagram Development

Care Network Rationale

Care	Netv	vork	Diag	rams

Data Visualizations posted at http://atlasofcaregiving.com/wp-content/uploads/2016/03/Data Visualizations.pdf

34

The "Data Visualizations" document contains 237 unique diagrams

Care Network × 14 participants

24-hour Log × 18 participants

Body 3 plots × 19 participants = 57

Environment 3 plots × 8 participants = 24

36-hour Log 2 plots × 18 participants = 36

Activities 2 plots \times 18 participants = 36

Motion × 7 participants

Floorplan × 7 participants

Photo Log × 20 participants

Summary × 18 participants

Care network for Fay ×14 additional participants

Dubberly Design Office · Designing a Prototype-Atlas of Caregiving · July 25, 2016

More than 2 hours away

Ο

Family friend 2

36
36-hour log for Fay ×18 additional participants

ACTIVITIES BROKEN OUT



Activity log for Fay ×18 additional participants





	MINUTES SPENT ON CAREGIVING	
36	Medications and supplements (including injections, IVs, o	ox
	Exercise, physical therapy	
	Equipment preparation and maintenance	
17	Wound management	
	Tracking symptoms and body measurements (weight, ter	mp
	Preparing special meals	
	Arranging appointments	
	Communicating with health professionals	
	Visits with health professionals	
	Buying prescriptions and supplies	
	Insurance and payments	
	Researching conditions and treatments	
	Researching healthcare costs	
	Keeping family and friends informed	
	Managing family and paid caregivers	
	Managing community services (paratransit, meals on wh	iee
	Bathing and toileting	
	Dressing and grooming	
6	Feeding	
	Getting in/out of bed, chair, etc	
	Moving around the home	
	Cleaning	
9	Cooking	
5	Laundry	
77	Shopping	
12	Getting/Moving/Using things	
22	Managing bills and savings	
60	Transportation to/from home	
32	Companionship	
37	Emotional support	
38	Plan and support participation in social activities	
5	Be constantly "on alert" for any needs	
	Be "on-call" for problems	

xygen, etc.)

Medical Activities

np, etc.)

Healthcare Management

Care Communication & Coordination

eels, etc.)

"ADLs" Help with Personal Activities

"IADLs" Household Chores

Social Support

Be Available

Total

Photo log for Fay ×20 additional participants





Black squares replace recognizable faces to ensure privacy.

Gray squares indicate when participants turned the camera off.

White squares indicate the start and stop of the study.

There were 974 photos for Fay alone.

Counts depend on study length; one participant had over 1,500 photos.

Dubberly Design Office · Designing a Prototype-Atlas of Caregiving · July 25, 2016

2015-08-31T195724.jpg 2015-08-31T195824.jpg 2015-08-31T195957.jpg 2015-08-31T201731.jpg 2015-08-31T201801.jpg 2015-08-31T201834.jpg 2015-08-31T201904.jpg 2015-08-31T201934.jpg 2015-08-31T202006.jpg 2015-08-31T202036.jpg 2015-08-31T202106.jpg 2015-08-31T202138.jpg 2015-08-31T202208.jpg 2015-08-31T202310.jpg 2015-08-31T202340.jpg 2015-08-31T202747.jpg -2015-08-31T202843.jpg 2015-08-31T221547.jpg 2015-08-31T221617.jpg 2015-08-31T221747.jpg 2015-08-31T223000.jpg 2015-08-31T223030.jpg 2015-08-31T223100.jpg 2015-08-31T223131.jpg 2015-08-31T223201.jpg 2015-08-31T223231.jpg 2015-08-31T223303.jpg 2015-08-31T223333.jpg 2015-08-31T223403.jpg 2015-08-31T223434.jpg 2015-08-31T223504.jpg 2015-08-31T223534.jpg 2015-08-31T223608.jpg 2015-08-31T223638.jpg 2015-08-31T223708.jpg 2015-08-31T223740.jpg 2015-08-31T223811.jpg 2015-08-31T223841.jpg 2015-08-31T223912.jpg

2015-08-31T2230/2 ind

1



Body sensor diagrams for Fay ×19 additional participants



Environmental sensor diagrams for Fay ×8 additional participants



Motion sensors diagram for Fay ×7 additional participants



Floorplan with sensor locations for Fay ×7 additional participants





SmartThings motion sensor



Netatmo weather station

Summary diagram for Fay ×18 additional participants



Analyzing Fay's summary diagram for insights—afternoon



Analyzing Fay's summary diagram for insights—night



Analyzing Fay's summary diagram for insights—morning



PART FOUR

Visualizations: How was the data processed?

We created the 'Diagram Development' document to capture all the details that went into the making of the data visualizations.

Study Report





Diagram Development





Diagram Development posted at http://staging.dubberly.com/atlas/160504-Final Documents/AoC Development 160505a.pdf

Care Network Rationale













50

This project included help from 15 people.



John Cain Sapient Sensor and data expert



Peter Binggeser Sapient Sensor and data expert



Aniket Bhatnagar Sapient Sensor and data expert



Pasindu Wewegama Sapient Sensor and data expert



mPath

Sensor expert



Dawn Nafus Intel Ethnography



Patch Kessler Tyto Life Data wrangling, filtering, and MatLab graphing



Hugh Dubberly Dubberly Design Office Co-Principal Investigator



Robin Bahr Dubberly Design Office Project management



Ryan Reposar Dubberly Design Office Design, data wrangling, and production



Paul Souza Dubberly Design Office Exploration, data wrangling, and design.



Knut Synstad Dubberly Design Office Design and production



Rajiv Mehta Bhageera Principal Investigator



Shalin Mehta Coding and production



Cody Wackerman Dubberly Design Office Design, coding, and production

The team used a wide range of tools.





A detailed production matrix let us know where we were in the process.

1 Care Network	Sketch Draw Design	Sketch Draw Design	Sketch Draw Design	Sketch Draw Design	Sketch Draw Design			Sketch Draw Design		Sketch Draw Design	Sketch Draw Design	Sketch Draw Design	Sketch Draw Design		Sketch Draw Design	Sketch Draw Design		Sketch Draw Design	Sketch Draw Design	
2 24-hour Log	CSV Design Upload to WP Download SVG	No data collected	CSV Design Upload to WP Download SVG	No data collected	CSV Design Upload to WP Download SVG															
36-hour Log 3 Broken out 4 Combined	CSV Design Upload to WP Download SVG	No data collected	CSV Design Upload to WP Download SVG	No data collected	CSV Design Upload to WP Download SVG															
Activities 5 Hours spent 6 Minutes spent	CSV Design Upload to WP Download SVG	No data collected	CSV Design Upload to WP Download SVG	No data collected	CSV Design Upload to WP Download SVG															
7 Photo Log	Design Run script Export SVG	Design Run script Export SVG	Design Run script Export SVG	Design Run script Export SVG	Design Run script Export SVG	Design Run script Export SVG	Design Run script Export SVG	Design Run script Export SVG	Design Run script Export SVG	Design Run script Export SVG (+ Wanda's room)	Design Run script Export SVG	Design Run script Export SVG	Design Run script Export SVG	Design Run script Export SVG						
Body89Heart Rate10Movement	CSV Design Process in MatLab	CSV Design Process in MatLab	No data collected	CSV Design Process in MatLab	CSV (3 files) Design Process in MatLab	CSV Design Process in MatLab	CSV Design Process in MatLab	CSV Design Process in MatLab	CSV Design Process in MatLab	CSV (battery died) Design Process in MatLab										
Environment 11 CO2 12 Humidity 13 Noise	No data collected	Data in DD Design Download SVG	Data in DD Design Download SVG	Data in DD Design Download SVG	No data collect (unknown tech	red nical problems)		No data collec	ted	Data in DD Design Download SVG		No data collected	Data in DD Design Download SVG		No data collected	No data collected				
Motion 14 Motion 15 Floorplan	No data collected No floorplan	Data in DD Design Download SVG Floorplan	Data in DD Design Download SVG Floorplan	Data in DD Design Download SVG Floorplan	No data collected No floorplan			No data collected No floorplan		Data in DD Design Download SVG Floorplan	No data collected (hotspot failure?) No floorplan	Data in DD Design Download SVG Floorplan	Data in DD Design Download SVG Floorplan		No data collected No floorplan	Data in DD (on Design Download SVG Floorplan	ily 1 day)	No data collected No floorplan	No data collected No floorplan	
16 Summary	Design - 36-hour Log - Body - Environment - Motion	Design - 36-hour Log - Body - Environment - Motion (insufficient data)	Design - 36-hour Log - Body - Environment - Motion	Design - 36-hour Log - Body - Environment - Motion (insufficient data)	Design - 36-hour Log - Body - Environment - Motion															
	1 Ana	2 Chantal	3 Fay	4 Gabrielle	5 Hanna	6 Gaston	7 Harvey	8 Fernando	9 Laura	10 Ida	11 Nadine	12 Odette	13 Nate	14 Patty	15 Sally	16 Tammy	17 Rafael	18 Teddy	19 Omar	20 Cindy

Care Network We iterated and refined the design over the course of the project.



Refinements



Rationale



Care Network We created a design rationale document which explains our decisions.







Care Network Rationale



Care Network Rationale posted at http://staging.dubberly.com/atlas/160504-Final Documents/AoC Care Network Diagram Style 160505a.pdf









Activity Logs We used D3 (Data Driven Documents) to visualize the hand-written participant logs.

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Photo Log

We wrote a script to select a subset of photos and used NodeJS to lay them out in a grid. We also shared our code on GitHub.



https://github.com/dubberlydesign/photogrid



Body Sensors

Many applications—including specialized data visualization tools could not handle the amount of data collected.

Date & Time	BVP	EDA	HR	x	у	z	moving AVG ACC
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Tableau could open the data files, but it didn't offer vector output, which was a design requirement (to enable zooming into SVGs).

expert user.



MatLab met our needs but required file conversion which took 20 hours (1 hour per participant), and an

Body Sensors We gathered more data than we could show. It needed to be downsampled, but how much?





EDA sampled once every 15 seconds 8640 data points

EDA sampled once every 30 seconds 4320 data points

60

(2160 is 2 × 1080, a common screen resolution.)



EDA sampled once every 60 seconds

2160 data points

Body Sensors How the diagrams would be presented helped guide our decision. 2 minutes in the data equals 1 point in the diagram.



Body Sensors

EDA data spiked unexpectedly in the middle of the night. Was the participant stressed in a lucid dream? Or did they simply get too hot under their blankets?



Body Sensors The spike would have to be removed, but how?

In the context of EDA data, "slow" (tonic) and "fast" (phasic) seem to refer to a slow moving baseline, and then fluctuations around that baseline.

We ran a transform on the data which looked for rapid fluctuations and smoothed them out.



Body Sensors **Comparison of the original, unfiltered data, with the final, filtered data.**



Environment and Motion Sensors

Manufacturer's software could be even more powerful. Sapient gave us access to more powerful tools they've developed.







Results: What did we learn?

65

Conclusions

- Special sensors can measure stress in lab settings and in highly controlled studies; however, even the very best consumer devices do not yet provide useful stress data in uncontrolled general use though opportunities for correlating stress and other data abound.
- Off-the-shelf sensors are here, but processing the data requires special knowledge of specialized tools.
- Healthcare—and the rest of our lives—are about to experience an explosion of sensor-generated data.

IoT devices in homes will produce and collect massive amounts of data:

- Appliances
- Computers + Entertainment
- Electrical
- Gas
- Health
- -HVAC
- Plumbing
- Privacy
- Security
- Transportation



Sensors will be ubiquitous: at checkpoints, logging everything you do online, all around you, on you, and in you.



Dubberly Design Office · Designing a Prototype-Atlas of Caregiving · July 25, 2016

Information + Tools + Coaching

What does this mean? Massive data collecting organized into a taxonomy of personal identity



Dubberly Design Office · Designing a Prototype-Atlas of Caregiving · July 25, 2016

Hobbies Media Performances × Sports

Create/Participate Curate/Coach Comment Consume

Grooming + Prevention Body Systems Emotions + Affect Exercises + Diet

Drilling into a sub-categories shows the potential for detail;

Today lab tests can measure over 150 analytes; more tests are in development.



Pituitary gland

(nydrocortisone)	Normai, PMI: 3–17 µg/dL
17 Hydroxyprogesterone * See also: ovaries	Man, normal: .06–3 mg/L Woman (follicular phase), normal: .2–1 mg/L
Angiotensin- converting enzyme (ACE)	Normal: 23–57 U/L
Growth hormone	At peak: 5–45 ng/mL Between peaks: < 5 ng/mL
Follicle-stimulating hormone (FSH)	Prepubertal: < 1 – 3 IU/L Adult male: 1–8 IU/L Adult female (follicular & luteal phase): 1–11 IU/L Adult female (ovulation): 6–26 IU/L Post-menopausal female: 30–118 IU/L
Adrenocorticotropic hormone (ACTH)	Normal: 20–80 pg/mL
Prolactin	Female, normal: < 20 ng/mL Male, normal: < 15 ng/mL
Blood Glucose	Hypoglycemia: < 3 mmol/l Normal: 3.6–5.8 mmol/l Normal, post-meal: <10 mmol/l Hyperglycemia: > 7 mmol/l (chronically)
Luteinizing hormone (LH)	Female (peak): 20–75 IU/L emale (post-menopausal): 15–60 IU/L
Insulin absorption	-
Plasma osmolality	Normal: 275–295 mOsm/kg
Total cholesterol	

Unified patient and device data will afford useful views to many constituents.



New machine learning systems will look for patterns, identify signals of risk, and warn patients and caregivers of impending problems.



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Looking to the future

- New IoT devices, including robots, are entering the home and medical markets.
- These devices, plus a new generation of more precise sensors suggest potential for a follow up study.
- Increasingly sensors will detect bio-markers leading to more personalized medicine.
- Over the next several years, IoT devices and sensors will become an integral part of healthcare—especially managed care. And managed care organizations will become increasingly concerned about family caregiving.

All the documents mentioned in this talk are available online.

Study Report



Data Visualizations



Diagram Development



Care Network Rationale

- Teleo	or our ogiving
Ca Dia	e Network Diagrams gram Style Rationale
Vestion 13	
Propared for Rajiv Metza	

Study Report posted at http://atlasofcaregiving.com/wp-content/uploads/2016/03/Study_Report.pdf Data Visualizations posted at http://atlasofcaregiving.com/wp-content/uploads/2016/03/Data_Visualizations.pdf Diagram Development posted at http://staging.dubberly.com/atlas/160504-Final_Documents/AoC_Development_160505a.pdf Care Network Rationale posted at http://staging.dubberly.com/atlas/160504-Final_Documents/AoC_Care_Network_Diagram_Style_160505a.pdf Learn more about the project at http://atlasofcaregiving.com



Website









Special thanks to Robert Wood Johnson Foundation Rajiv Mehta Ryan Reposar

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Presentation posted at presentations.dubberly.com/designing_a_prototype.pdf