ARTICLE

The aspect of time in online health information behaviour: a longitudinal extensive analysis of the Suomi24 discussion forum

Jonas Tana
Department of Healthcare, Arcada University of Applied Sciences, Helsinki, Finland; Information Studies, Faculty of Social Sciences, Business and Economics, Åbo Akademi University, Turku, Finland
jonas.tana@arcada.fi
https://orcid.org/0000-0002-6821-1571

Emil Eirola
Department of Business Management and Analytics, Arcada University of Applied Sciences, Helsinki, Finland
https://orcid.org/0000-0001-7404-977X

Kristina Eriksson-Backa
Information Studies, Faculty of Social Sciences, Business and Economics, Åbo Akademi University, Turku, Finland
https://orcid.org/0000-0001-9758-0467

Temporal structures and rhythmicity are universal phenomena and affect all aspects of life, including dynamic processes like health and well-being that change over time. Health related issues and threats trigger health information behaviour, a majority of which happens online and thus leaves digital traces behind. This study analyses the temporal variations and rhythmicity of health information behaviour through the action of online posting in a large Finnish discussion forum, Suomi24. The findings in this study show that health information behaviour follow clear and robust rhythmicity on both a seasonal and daily level. This endorses the notion that well-being, health and illness are dynamic processes that change with time and can help provide a more holistic picture of health and well-being, including aspects that fall outside professional healthcare settings. Studying when health information behaviour happens can thus have wide-ranging consequences.

Keywords: health information behavior, health, social media, time, temporality

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Introduction

Temporal structures of days, weeks, months, and seasons, affect all living things, from single cells to human beings. Rhythmicity and temporal patterns related to sleeping, breathing, eating, thinking and issues of health and illness are universal phenomena (Adam, 1990; Mogilner et al., 2018; Reinberg et al., 2017; Roenneberg, 2012;). Especially well-being, health and illness are all dynamic processes that change over time, placing individuals on a discontinuous and cyclical spectrum ranging from health, well-being and optimal function on one end to illness and death on the other end (Eriksson, 1993; Henly et al., 2011; Svalastog et al., 2017). This discontinuous nature is closely associated with health information behaviour or how people seek, obtain, evaluate, categorise, use and share health-related information in regards to their health and illness (Ek, 2013). Within the health and illness continuum, the health issues and threats that individuals face have been suggested to trigger health information behaviour, which is essential in regards to coping and maintaining proper health and health behaviours (Ek, 2013; Lambert and Loiselle, 2007). These issues that individuals face, might develop or evolve at any time during the day, week, month or year. A majority of these issues fall outside the scope of traditional healthcare systems, as between seventy to ninety per cent of all health related problems are solved or managed without the involvement of healthcare professionals (McGowan, 2002; Oliphant, 2010; Siepmann, 2008). Thus, a substantial amount of relevant data about different health behaviours is left undocumented and unexplored. Today, a majority of health information behaviour happens online, leaving behind digital traces in search engines, social media and on websites (Hausner et al., 2008; Kim and Oh, 2011; Lee et al., 2014). Internet use as a source for information related to health or illness in Finland is, and has for quite some time already, been ubiquitous, which makes studying online traces justifiable (Ek et al., 2013; Tilastokeskus, 2017). Studying and systematically analysing this rising amount of web data and digital traces from a temporal perspective can reveal evidence of rhythmicity, and reveal temporal patterns, trends and variations of health information behaviour (Ayers et al., 2014; Eysenbach, 2011). This type of research or approach has been dubbed infodemiology, and is rooted in the idea that there is a relationship between population health on one hand, and information and communication patterns on the internet, on the other (Eysenbach, 2009).

The purpose of this study is to identify and analyse the rhythmicity of health information behaviour through the action of online posting in a large Finnish discussion forum, Suomi24. Health information behaviour in this study can therefore entail seeking or obtaining, as well as evaluating or disseminating

health information by either asking or answering questions, or posting comments in relation to these or in general. By answering the question of *when* Finnish people are engaged in health information behaviour, we bring focus to time, a context that has been somewhat overlooked in information science. Studying health information behaviour in relation to time can allow for anticipation and prediction of discontinuities and knowledge gaps in relation to health, as well as enhance our understanding of factors that influence change in health over time (Adam, 1990; Ayers et al., 2014). This could also, especially for health related issues where individuals have been shown not to seek help from professionals, both complement epidemiological data and provide a more holistic picture of health and well-being, including new insights for previously unknown or undocumented aspects of health behaviours and their temporal nature (Eysenbach, 2011). As health is a dynamic process bound by rhythmicity and different temporal structures, knowledge about when individuals are focusing their attention on health threats, engaging in health related behaviour and in need of, as well as receptive to, support, can help in providing temporally optimal and effective interventions (Ayers et al., 2014; Svalastog et al., 2017). As Finland is geographically positioned in the north with intense variations in both temperature and photoperiod during the day and year, we hypothesise that there are clear daily and monthly, or seasonal, temporal patterns, trends and variations of health information behaviour.

Temporal aspects in information science

The context of time has traditionally received little attention in information science research, theory building and practice, as focus usually favours and emphasises spatial issues (Adam, 1990; McKenzie and Davies, 2002; Solomon, 1997). Overall, research on the temporal aspects of information behaviour are scarce, even if several information behaviour researchers have highlighted the importance of studying the aspect of time (McKenzie and Davies, 2002; Dervin 1992; Savolainen, 2006; Savolainen, 2018; Solomon, 1997).

Within information science, time has, according to Savolainen (2006; 2018), been approached as a qualifier of access to information, as an indicator of the information-seeking process and as a fundamental attribute of situation or context of information seeking, or the general time concepts surrounding life and situations therein. Situation or context can in the last mentioned approach be seen as the moment in time space, as perceived by an individual (Savolainen, 2006). This view of time as a situation or context touches, as Savolainen (2018) states, on Dervin's Sense-making approach.

Dervin's Sense-making is implemented in terms of four different constituent elements: *situation*, *gap*, *outcome* and *bridge* (Dervin, 1999; Wilson, 2000). From a temporal perspective, and for the focus of this study, the Sense-making element of situation is highly relevant, as it defines the context, in this case the specific time or instance, in which an individual identifies a need for information or an information problems arises. In this situation, the individual is prevented from continuing the journey through time-space (Dervin, 1992). The approach is rooted in the notion that life and reality, much like health and illness, is discontinuous, gap filled and changeable across time and space. This affects basic issues of human welfare, and individuals within this time-space need to make sense of these knowledge gaps, problems and discontinuities (Case, 2012; McKenzie and Davies, 2002; Dervin, 1992). Information seeking is only one action within these situations or response to these knowledge gaps, and Sense-making also includes other information behaviour, like seeking or providing reassurance, expressing or sharing feelings, and connecting with others (Case, 2012). Studying these gaps and situations can reveal the actions or instances in sense-making (Dervin, 1998).

Within the different elements of Sense-making, different kinds of time not only receive attention, but the view of time is fundamental to the approach, and the conceptualisation of time is central to any attempts to predict or explain information behaviour (Dervin, 1999). Dervin advocates that the study of these situations or gaps has to take place in context (Ormandy, 2010). This mandate to study temporal aspects allows for the possibility of conceptualising health information behaviour as temporally patterned, and opens up for the possibility to observe rhythms, variations and patterns that change in response to changing situational conditions or contexts, like seasonal changes or the different hours of the day (Dervin, 1999; 2005). Therefore, the temporal aspect of these situations where knowledge gaps occur is an important factor, especially on a collective level, as it can reveal rhythmicity for some behavioural patterns. This emphasises that *when* an individual seeks information is as important as what he or she seeks (McKenzie and Davies, 2002).

Despite a long-time interest in temporal issues, the temporal nature of information behaviour is still, as stated, an underexplored or overlooked topic (McKenzie and Davies, 2002; Savolainen, 2018). Time, as expressed in information dynamics has, as Solomon (1997) states been difficult to capture and comprehend. Reasons for this have been suggested to be methodological, as traditional data gathering methods like surveys or interviews often leave temporal variations and rhythms, except some annual or seasonal, outside the scope of data collection (Anker et al., 2011; Ayers et al., 2014). These more traditional methodologies tend to only provide "snapshots" or "still photos" of

health behaviour in relation to time, as well as portrait information behaviour based on characteristics of individuals assumed to be constant across time-space (Anker et al., 2011; Dervin, 2005). This is sufficient, and as Dervin and Nilan (1986) propose, information behaviour should be captured as a movement in time-space, as individuals are different at different moments in time-space, moving linearly from past to present to future (Savolainen, 2018). However, time can also be perceived as a cyclic phenomenon, from the perspective and recognition of repetition of behaviours, for instance behaviours related to health (McKenzie and Davies, 2002; Dervin, 1992). Savolainen (2018) points out that, if looking at a particular season or day, one could argue that they are not cyclical because they do not reoccur in a similar fashion. However, especially within health information behaviour, reoccurring temporal trends and patterns can occur when considered collectively, providing evidence for rhythmicity in health information behaviour.

Studying rhythmicity of health information behaviour has in the recent years become increasingly popular. Research has mostly focused on specific diseases and their symptoms in either social media, search engines or on web pages (Guy et al., 2012; Zeraatkar and Ahmadi, 2018). These studies include analysing social media data for pandemics (Chew and Eysenbach, 2010; Ortiz-Martínez and Jiménez-Arcia, 2017; Seo and Shin, 2017) as well as mood swings and depression (Chen et al., 2018). Search engine data has been utilised to investigate a multitude of illnesses and health issues, like mental health issues (Arendt and Scherr, 2017; Ayers et al., 2013; Tana et al., 2018; Tana, 2018), chronic diseases and symptoms (Basnet et al., 2016), diabetes (Tkachenko et al., 2017), different virus and influenza outbreaks (Bragazzi et al., 2017; Carneiro and Mylonakis, 2009; Kraut et al., 2017; Osuka et al., 2018), transient ischemic attack (Abedi et al., 2015), status epilepticus (Brigo and Trinka, 2015), exercise and weight loss (Madden, 2017), as well as Lyme disease (Pesälä et al., 2017; Seifter et al., 2010). Web traffic again has been utilized for studying accessing health information on the internet related to different topics, such as suicide-related information and pharmacovigilance (Wong et al., 2013; Matsuda et al., 2017). However, research on temporal variations and patterns of health and illness utilizing discussion forum metrics are scarce. Halder, Poddar and Kan (2017) examined temporality in relation to mental health and online forums. They studied the problem of predicting a patient's future emotional status based on past forum posts. Paul and colleagues (2016), on the other hand, studied demographic and temporal trends connected with use of drugs that could be found in an online forum. Nimrod (2013) again analysed some key trends in English-based online depression communities in terms of level of activity in relation to seasonal changes. To

the best of our knowledge, this is the first study within information science to longitudinally study the context of time and rhythmicity in relation to health information behaviour in an online discussion forum.

Methods and data

Suomi24 (`https://www.suomi24.fi/`) is Finland's largest and most popular discussion forum. The free and anonymous discussion forum had 832,000 unique visitors and 17 million page loads per week during 2015 (Aller, 2016). In 2018, Suomi24 still had a monthly reach of over 2 million internet users, making it the 8th most popular Finnish internet site (FIAM, 2018). Statistics show that in 2014, 24% of the Finnish population aged 16-89, 40% of people aged 16-34 and 35% in the age category 35-44 had posted something to a discussion forum (Tilastokeskus, 2017).

The entire discussion forum database, including all 82,858,608 messages ranging from January 1st 2001 to December 31st 2017, is available for research purposes as open data, and can be downloaded through FinCLARIN's Kielipankki Korp-interface (`http://urn.fi/urn:nbn:fi:lb-2019010801`). The data is offered as a custom VRT format ("verticalised text"), which represents a parsed version of the text for each posted message on the forum. The forum itself contains several different main topics, including health. The health (fi. *terveys*) category encompasses 3,788,224 messages and represents 4.57% of the discussion forum messages. The health category is divided into sixteen sub-topics, of which some are further divided into different sub-categories that relate to the sub-topic, all provided by Suomi24 (see Table 1). The number of messages within the different sub-topics and sub-categories can also be seen in Table 1. Discussions in the Suomi24 discussion forum follow a general discussion forum structure with threads containing original posts, replies and comments to replies. As the number of messages is excessively high, the analysis is due to practical reasons limited to sub-topics and sub-categories that contain more than 100.000 messages and that show the largest temporal variations based on the ratio between maximum and minimum relative share of messages on a seasonal and daily level. With these limitations, the sub-topics and sub-categories included in this study are: Alcohol, Alternative treatments, Birth control, Depression, Drugs, Eating disorders, General mental health, Internal medicine, Loneliness, Mental health and well-being, Narcissism, Weight control, Weight loss and Women's health. These 14 sub-topics and sub-categories are also marked with bold font in Table 1.

The univariate analysis in this study examines the metadata of the posts, in

particular the time of posting, and the topic, sub-topic and sub-category. The content of messages is not included in the scope of this study. The data files are processed using Python with the Python Data Analysis Library "pandas" and plotting library "matplotlib". The messages are binned and counted according to the time of posting and category. Calculating this at different aggregation levels reveals particular temporal patterns in the data. E.g., when binning the posts by hour, and aggregating over all days in the data, the resulting distribution represents the average daily variation in posting intensity. Similarly, the posts are separately binned by date, and aggregated over the 17 years, although a rolling triangular window of 15 days is applied here in order to smooth out the effect of random fluctuation and reveal more enduring patterns. To exclude the general variation in overall posting intensity between the years 2001 and 2017, as well as accentuate the differences between categories of interest, the relative shares of messages within any bin is calculated. This measures by how much the categories are over-represented or under-represented, compared to the overall rate in the Health category.

Table 1. Number of messages for the different sub-topics and subcategories in the Suomi24 discussion forum.

Sub-Topic	**Sub-category**	**Messages**
Senses (*fi. Aistit*)	No subcategory	80
	Hearing (*fi. Kuulo*)	15561
	Other senses (*fi. Muut aistit*)	46
	Seeing (*fi. Näkö*)	49749
Birth control (*fi. Ehkäisy*)	No subcategory	103044
Mental health and wellbeing (*fi. Henkinen hyvinvointi ja mielenterveys*)	No subcategory	4550
	Anxiety (*fi. Ahdistus*)	16841
	Bi-polar disorder (*fi. Kaksisuuntainen mielialahäiriö*)	23156
	Depression (*fi. Masennus*)	169810
	Narcissism (*fi. Narsismi*)	138909
	Obsessive compulsive disorder (*fi. Pakko-oireinen häiriö*)	8648
	Panic disorder (*fi. Paniikkihäiriö*)	44000
	Fears and tensions (*fi. Pelot ja jännitys*)	39797
	Schizophrenia (*fi. Skitsofrenia*)	12021
	Stress and burn-out (*fi. Stressi ja burn-out*)	7315
	Shyness (*fi. Ujous*)	19971
	Sleep and sleep disorders (*fi. Uni ja unihäiriöt*)	30240

	Loneliness (*fi. Yksinäisyys*)	162409
	General mental health (*fi. Yleistä mielenterveydestä*)	133245
Death and grief (*fi. Kuolema ja suru*)	No subcategory	59707
Ask about health (*fi. Kysy terveydestä*)	No subcategory	45219
Medications (*fi. Lääkkeet*)	No subcategory	92495
Mens health (*fi. Miesten terveys*)	No subcategory	1586
	Erectile dysfunctions (*fi. Erektiohäiriö*)	40558
	General mens health (*fi. Yleistä miesten terveydestä*)	911
Womens health (*fi. Naisten terveys*)	No subcategory	1657
	Menstruation (*fi. Kuukautiset*)	44052
	Obstetrics (*fi. Naistentaudit*)	59740
	Menopause (*fi. Vaihdevuodet*)	30677
Weight control (*fi. Painonhallinta*)	No subcategory	1091
	Underweight (*fi. Alipaino*)	193
	Weight loss (*fi. Laihdutus*)	521481
	Obesity (*fi. Lihavuus*)	75960
Plastic surgery (*fi. Plastiikkakirurgia*)	No subcategory	77722
Drugs and addictions (*fi. Päihteet ja riippuvuudet*)	No subcategory	529
	Alcohol (*fi. Alkoholi*)	196814
	Alcoholism (*fi. Alkoholismi*)	8408
	Drugs (*fi. Huumeet*)	147559
	Hangover (*fi. Kankkunen*)	6657
	Internet addiction (*fi. Nettiriippuvuus*)	1698
	Gambling addiction (*fi. Peliriippuvuus*)	7411
	Drug policy (*fi. Päihdepolitiikka*)	8978
	Drugs (*fi. Päihteet*)	7446
	Smoking (*fi. Tupakointi*)	46927
	Peer-support (*fi. Vertaistuki*)	409
Diseases (*fi. Sairaudet*)	No subcategory	1100
	Allergies and asthma (*fi. Allergiat ja astma*)	37631
	Diabetes (*fi. Diabetes*)	39445
	Mould health issues (*fi. Homesairaudet*)	93192
	Skin diseses (*fi. Ihotaudit*)	133955
	Respiratory diseases (*fi. Keuhkosairaudet*)	10247
	Migraine (*fi. Migreeni*)	11667
	Neurological diseases (*fi. Neurologiset sairaudet*)	107120
	Pandemics (*fi. Pandemiat*)	49995
	Internal medicine (*fi. Sisätaudit*)	167686
	Eating disorders (*fi. Syömishäiriöt*)	116416

	Cancer (*fi. Syöpä*)	54120
	Musculoskeletal disorders (*fi. Tuki- ja liikuntaelinsairaudet*)	46242
	Common cold (*fi. Vilustuminen*)	12238
Oral health (*fi. Suun terveys*)	No subcategory	95310
Health care (*fi. Terveyden hoito*)	No subcategory	393
	Massage (*fi. Hieronta*)	15094
	Rehabilitation (*fi. Kuntoutus*)	4441
	Surgery (*fi. Leikkaus*)	29120
	Carers (*fi. Omaishoitajat*)	9652
	Alternative treatments (*fi. Vaihtoehtoiset hoidot***)**	148550
	Vitamines (*fi. Vitamiinit*)	23716
Healthcare services (*fi. Terveydenhoitopalvelut*)	No subcategory	3695
General health (*fi. Yleistä terveydestä*)	No subcategory	94267

The largest temporal variations within the different sub-topics and sub-categories are, as stated above, identified based on the ratio between maximum and minimum relative share of messages and presented in Table 2.

Table 2: Largest variations in yearly and daily rhythm for the different sub-topics and sub-categories based on the ratio between maximum and minimum relative share.

Largest variation in yearly rhythm	**Ratio**		**Largest variation in daily rhythm**	**Ratio**
Loneliness (*fi. Yksinäisyys*)	2.132096		Loneliness (fi. Yksinäisyys)	3.343914
Narcissism (*fi. Narsismi*)	1.945516		Depression (fi. Masennus)	2.697666
Weight loss (*fi. Laihdutus*)	1.833515		General mental health (fi. Yleistä mielenterveydestä)	2.546249
Eating disorders (*fi. Syömishäiriöt*)	1.818933		Weight loss (fi. Laihdutus)	2.516494
Alcohol (*fi. Alkoholi*)	1.811670		Drugs (fi. Huumeet)	2.513675
Weight control (*fi. Painonhallinta*)	1.784124		Alternative treatments (fi. Vaihtoehtoiset hoidot)	2.486138
Drugs (*fi. Huumeet*)	1.771270		Birth control (fi. Ehkäisy)	2.477815
Alternative treatments (fi. Vaihtoehtoiset hoidot)	1.738822		Mental health and well-being (fi. Henkinen hyvinvointi ja mielenterveys)	2.443714
Womens' health (fi. Naisten terveys)	1.682895		Weight control (fi. Painonhallinta)	2.191275
Internal medicine (fi. Sisätaudit)	1.632709		Eating disorders (fi. Syömishäiriöt)	1.968000

Results

The results in this study are reported in context of two different time-scales, yearly and daily, to identify seasonal as well as daily variations.

Seasonal variations

On a yearly or seasonal time-scale, rhythmicity in the Suomi24 discussion forum shows several variations compared to the baseline, the health category. As can be seen in Table 2, the sub-category with the largest variation in monthly or seasonal variation is Loneliness, the second largest sub-category within the sub-topic Mental health and well-being. Health information behaviour in relation to loneliness follow a bimodal curve, with the largest peak during Christmas, and another peak period during summer months (Fig. 1). The third most popular sub-category, Narcissism, within the same sub-topic, also shows clear variations during the year, but the pattern is somewhat more irregular than in the Loneliness sub-category, as can be seen in Figure 1. Health information behaviour in relation to narcissism peaks in the beginning of April, and shows smaller recurring peaks until late October, after which clear troughs are visible from November until March.

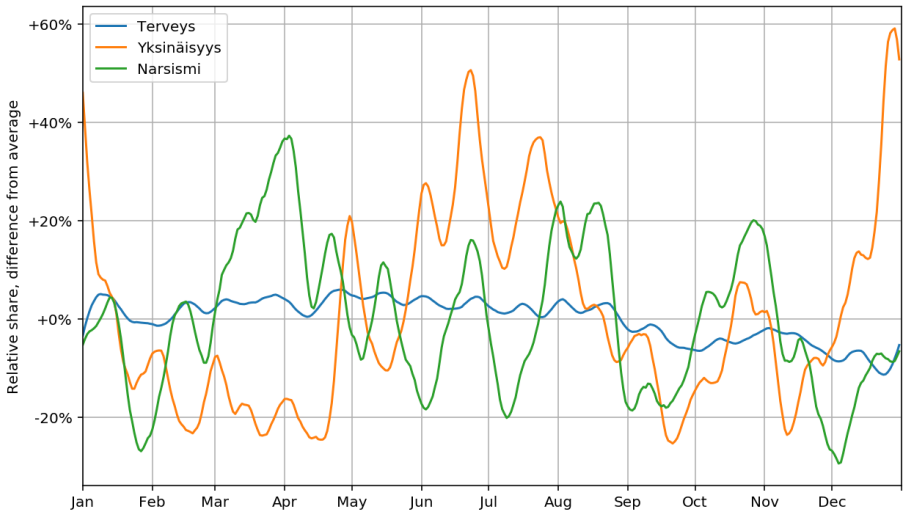

Figure 1. Yearly distribution of messages within the Loneliness (fi. Terveys) and Narcissism (fi. Narsismi) sub-categories.

Weight loss is by far the largest sub-category within the Weight control sub-topic with 521.481 messages. The yearly distribution of messages reveals, as can be seen in Figure 2, that the discussions within this sub-category follow a unimodal pattern, with increasing activity during the first months of the year, and a clear peak in late March. A decrease in number of messages is then visible towards the end of the year, with the lowest activity around Christmas, after which activity again starts to increase. The sub-topic Weight control shows a similar curve as Weight loss. As can be seen in Figure 2, a similar, even though a slightly lopsided curve is visible for Eating disorders, a sub-category within Internal Medicine. A peak in March is visible, but contrary to weight loss, health information behaviour in relation to eating disorders show increased activity during the summer. A smaller peak in the unimodal curve is also visible in the end of September.

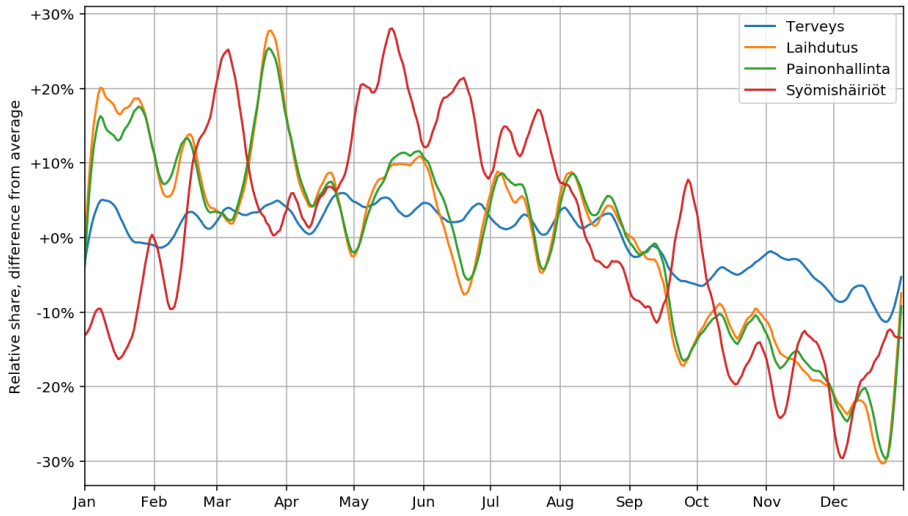

Fig 2. Yearly distribution of messages of the Weight control (fi. Painonhallinta) sub-topic and Weight loss (fi. Laihdutus) and Eating disorders (fi. Syömishäiriöt) sub-categories.

The two sub-categories, Alcohol and Drugs within the Drugs and addictions sub-topic show that health information behaviour in relation to these two themes follow clear seasonal rhythmicity (Figure 3). Alcohol follows a bimodal pattern, with highest peaks during Christmas and New Year as well as in mid-July. Troughs are visible in February, from mid-May to mid-June and from mid-October to mid-November. A bimodal pattern is also visible within the Drugs sub-category. However, peak times are somewhat different, with the highest peak in spring, more closely mid-April to mid-May. There are also lower repeated peaks in summer and early autumn. Messages decrease in late autumn and are below the baseline until early spring.

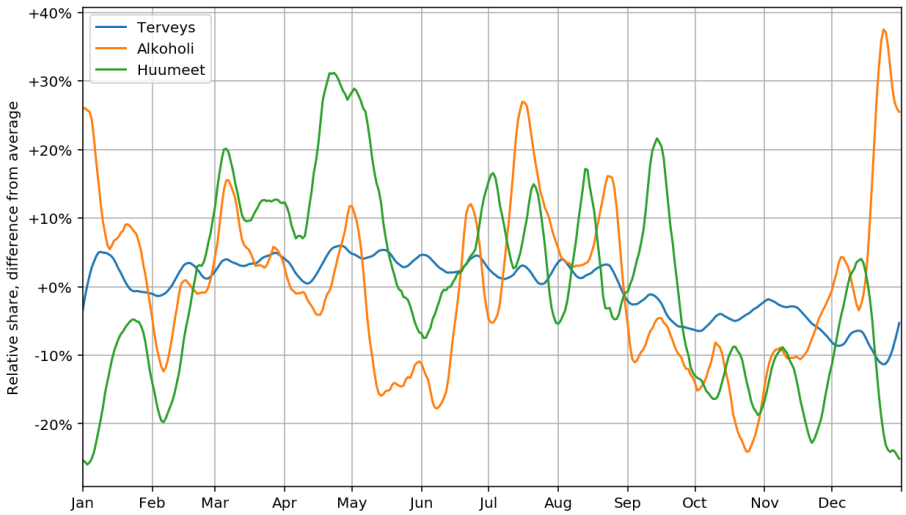

Fig 3. Yearly distribution of messages of the Alcohol (fi. Alkoholi) and Drugs (fi. Huumeet) sub-categories.

Alternative treatments, Women's health and Internal medicine also show clear variations on a seasonal level (Fig. 4). The yearly distribution of messages in the Alternative treatments sub-category shows the clearly highest peak after mid-April. A second, smaller peak follows in the beginning of June. After a mid-summer trough, two peaks are found in September and October. Women's health on the other hand follow a unimodal curve with peak season from mid-April to the beginning of August. The pattern reveals troughs in autumn, winter and early spring. Health information behaviour for topics relating to internal medicine peak in late winter and spring. The bimodal curve shows clear decreases in activity during summer and winter, especially mid-July and Christmas.

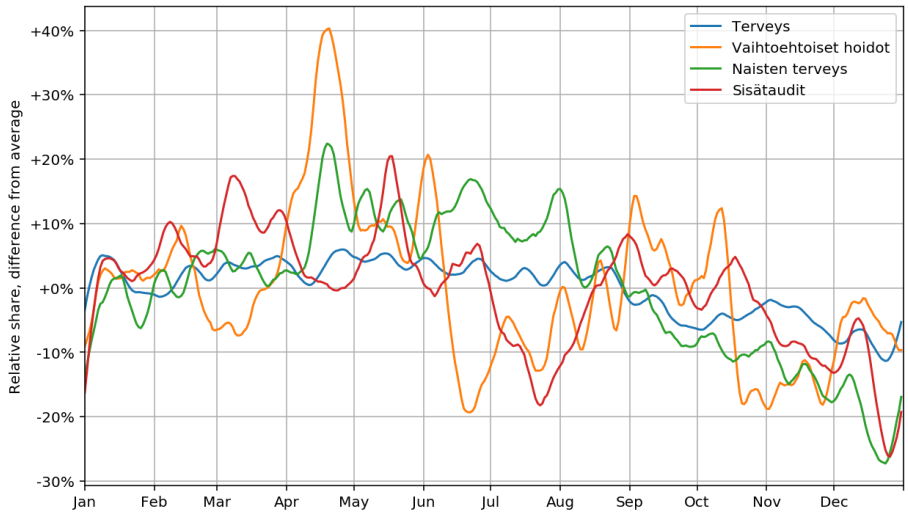

Figure 4. Yearly distribution of messages in the Alternative treatments (fi. Vaihtoehtoiset hoidot), Women's health (fi. Naisten terveys) and Internal medicine (fi. Sisätaudit) sub-categories.

Daily variations

The three largest daily variations in health information behaviour in the Health category of the Suomi24 discussion forum can be found within the Mental health and well-being sub-topic. These are: Loneliness, Depression and General mental health. All three categories follow a similar 24-hour pattern, where the distribution of messages follow a unimodal pattern, with a clear night time peak and day time trough. The same pattern can be found in the

Mental health and wellbeing sub-topic. This is illustrated in Figure 5. Even though the Health category in general follow a similar curve, the differences in relative shares are considerable.

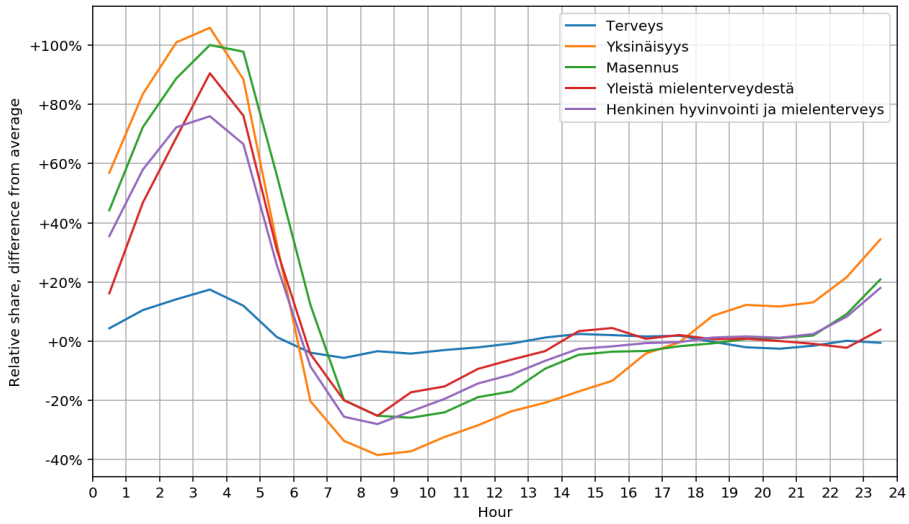

Figure 5. Daily distribution of messages in the Loneliness (fi. Yksinäisyys), Depression (fi. Masennus), General mental health (fi. Yleistä mielenterveydestä) sub-categories and the Mental health and wellbeing (fi. Henkinen hyvinvointi ja mielenterveys) sub-topic.

Similar night time peaks can be found in two other sub-categories with the largest daily variations in the Suomi24 discussion forum, Drugs and Eating disorders (Fig. 6). Especially Drugs follow a similar pattern, while the pattern in Eating disorders shows an increasing trend towards the evening, and a slightly earlier peak time, at between 01 and 02 in the night.

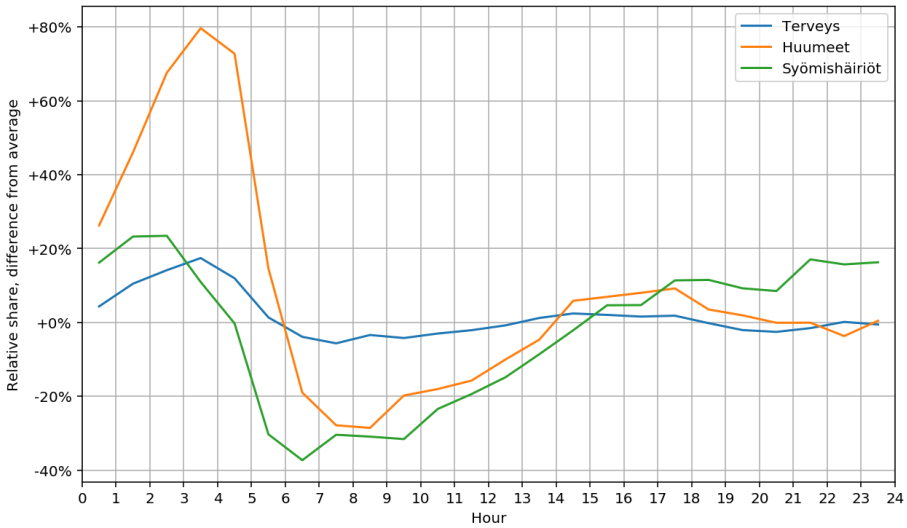

Figure 6. Daily distribution of messages in the Drugs (fi. Huumeet) and Eating disorders (fi. Syömishäiriöt) sub-categories.

A complete opposite curve to the night time peaks presented in Figures 5 and 6 can be found in the sub-topic Weight control and sub-category Weight loss (Fig. 7). Night time troughs are followed by clear and broader day time peaks, between 06 and 16, after which messages start to decrease. This pattern is also opposite to the pattern of the Health category in general.

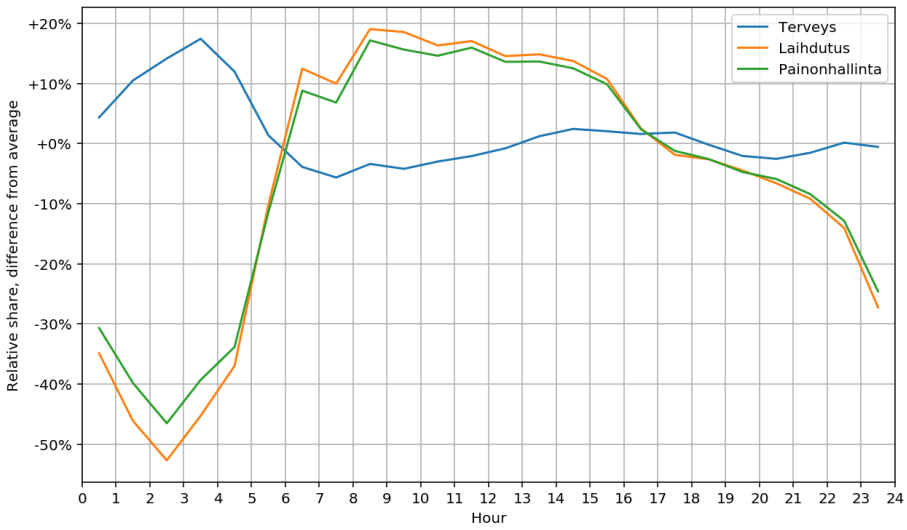

Figure 7. Daily distribution of messages in the Weight loss (fi. Laihdutus) sub-category and Weight control (fi. Painonhallinta) sub-topic.

A similar unimodal day time activity can be found in the Alternative treatments sub-category and the Birth control sub-topic (Fig. 8). The peak in health information behaviour related to Alternative treatments follow a similar pattern as Weight loss and Weight control to a larger extent than Birth control, where the peak is visible later during the day, in the afternoon.

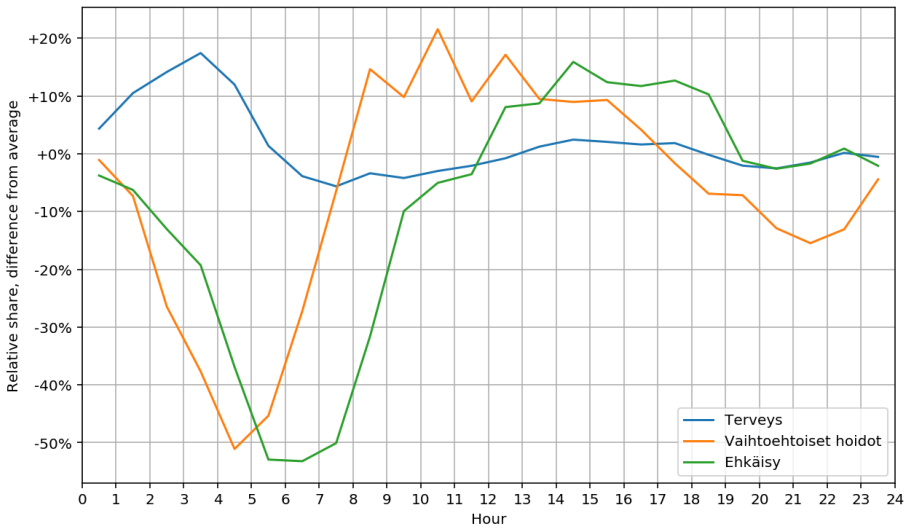

Figure 8. Daily distribution of messages in the Alternative treatments (fi. Vaihtoehtoiset hoidot) sub-category and Birth control (fi. Ehkäisy) sub-topic.

Discussion

As hypothesised, health information behaviour in the Suomi24 discussion forum shows clear and robust rhythmicity on seasonal and daily level. This is most evident for the themes analysed in this study, and endorses the notion that well-being, health and illness are dynamic processes, as suggested by earlier research (Eriksson, 1993; Henly et al., 2011; Mogilner et al., 2018; Reinberg et al., 2017; Roenneberg, 2012; Svalastog et al., 2017). Analysing digital traces of health information also provides evidence for understanding when people make sense of their health, as exemplified here by the Suomi24 data. Relating the findings in this study to previous research is for some parts challenging, as no previous studies have, to the best of the authors knowledge, been conducted that investigate the rhythmicity of health information behaviour in relation to some of the health issues and phenomena identified in this study. The results are nonetheless useful, as temporal variations in regards to

alternative treatments, birth control, women's health and internal medicine, can serve as initial steps to investigating these temporal variations and phenomena more thoroughly.

Examining daily variations on a more general level, mental health related issues including substance abuse and eating disorders, show a clear predisposition to be night time oriented, while more physical issues, such as birth control, alternative treatments, as well as weight control and loss show more activity during day time. This is similar to prior findings from Finland, where depression related health information seeking in search engines has been found to peak during night time (Tana et al., 2018). On a seasonal, as well as daily level, the Weight loss sub-category and Weight control sub-topic, with increased activity in the beginning of the year as well as the beginning of the day show signs of what has been called the "Fresh start effect". This kind of aspirational behaviour with a healthy new start has been identified in previous research, and implies that for some health related issues, beginnings such as New Year's, a new week or workweek, are times when people are motivated to pursue health related aspirations (Dai et al., 2014; Gabarron et al., 2015). Regarding alcohol related discussions on a seasonal level, the findings in this study support Mustonen et al. (2010) and Poikolainen et al. (2002) who found that alcohol consumption during the year peak in spring and especially around Eastern holidays, mid-summer and throughout the Christmas holidays. No studies similar to the one by Mustonen et al. (2010) have been conducted on drug abuse. In the sub-category Loneliness, which shows the clearest variations on both seasonal as well as daily variation, the health information behaviour rhythmicity observed in the Suomi24 discussion forum is similar to previous research findings. Loneliness has been found to share its seasonality with suicide, for which loneliness is a foremost cause (Sansone and Sansone, 2011). Suicides in Finland have been shown to peak in late spring and summer, often after an onset of depression (Hakko et al., 1998; Holopainen et al. 2013). However, the Christmas loneliness peak reported above can also be linked to previous findings of Velamoor et al. (1992), who found that the most common stressor of patients evaluated in a psychiatric emergency service during Christmas season was loneliness, and feelings of depression. As already mentioned, not all findings are relatable, and serve as preliminary findings for further research.

Limitations

This study has some limitations that need to be addressed. Primarily, all analyses in this study are of quantitative nature and limited to the timestamp in metadata, and therefore does not investigate the contents of, or reasons for the messages. Thus, the underlying causes or reasons for the different messages remain unclear. There is also a methodological bias present, as the data analysed in this study only concerns the part of the population that uses the internet and posts messages to discussion forums, in this case Suomi24, in matters regarding health. Related to this, there are no demographic data available in the Suomi24 data, which prevents from drawing conclusions on demographic characteristics. Furthermore, there are many other active discussion forums and social media in Finland on a general level, or in relation to specific illnesses and disorders, which are excluded from this study. However, as the aim of this study is to investigate rhythmicity of health information behaviour in the Suomi24 discussion forum, these limitations are of less concern for this study.

Implications

Knowledge about the rhythmicity and temporal aspects of health information behaviour can indicate, as well as help anticipate when Finnish people are more in need of, and receptive to, support in relation to specific health issues. Even if the identified clear and robust patterns and rhythms of health information behaviour are somewhat limited because of the lack of demographic data, the findings in this study can facilitate precautionary efforts within health promotion and prevention (Adam, 1990; Ayers et al., 2014). Knowledge about the rhythmicity of health information behaviour can support service design in creating cost-effective campaigns by targeting the population with right and relevant information at the right time to aid early and effective intervention (Wilson, 1999). This in turn can be beneficial for positive health outcomes (Lambert and Loiselle, 2007). Studying and identifying health related temporal rhythms for the Finnish population thus has strong potential for both behavioural as well as public health improvements.

Further directions

As already stated, there are many findings in this study that call for further and more thorough investigation. Some of the issues identified in this study could be investigated more thoroughly by analysing the content of the messages to provide answers as to why some phenomena exhibit clear variations on seasonal and daily level. Qualitative analysis could moreover provide answers not only to when, but also to *why*, *how* and *where*, providing insights into the remaining three constituents of Dervin's sense-making process. This could help identify differences between contextual and desired health related conditions, outcomes of the sense-making process as well as the means utilized for overcoming the knowledge gap. Analysing messages would also help identify different patterns and categories for specific information needs, use and sharing in relation to various health related phenomena. However, the overwhelming amount of content calls for novel data analysis methods, for instance from the field of big data analysis or artificial intelligence, such as natural language processing or sentiment analysis. Broadening the scope, from health to other issues and topics discussed in the Suomi24 forum could also provide useful insights into the rhythmicity of information behaviour on topics unrelated to health.

Conclusions

As the results in this study show, analysing digital traces can reveal clear and recurring rhythmicity in health information behaviour. This can potentially lead to the discovery of not only significant contextual dimensions, but also previously unknown or overlooked temporal rhythms of health issues. Longitudinal studies such as this, which in contrast to "snapshots" that surveys and questionnaires usually provide, help in identifying robust temporal patterns and variations, providing a more holistic picture of health and disease, including events and behavioural aspects that fall outside professional healthcare settings. As changes in health information behaviour patterns online could be symptoms of changes in population health, all aspects of online health information behaviour should be taken into account. Utilizing digital traces to investigate rhythmicity of health information behaviour allows us to understand when people make sense of their health and engage in health behaviours. Studying *when* health information behaviour happens can thus have wide-ranging consequences.

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