

## **Title: On features and measures of psychological wellbeing**

### **Abstract**

Low levels of psychological wellbeing pose considerable burdens on society in terms of mortality, unemployment, absenteeism, medications, social services, morbidity, and in-out patients' costs. Early detection and preventive treatments may help to reduce costs and improve quality of life. Researchers have proposed several measures and tried to identify new measures of psychological wellbeing, but there is not a universally accepted measure, and all the existing ones have their own limitations. This paper discusses research results focusing on behavioral, psychological, social, demographic features and biomarkers of psychological wellbeing and mental disorders associated with low psychological wellbeing levels. The features which are addressed in the paper are categorized into three groups: affecting features, features for therapy and detecting features. This categorization is described and defended.

**Keywords:** psychological wellbeing, subjective wellbeing, mental health, psychological wellbeing features.

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## Introduction

Psychological wellbeing (PWB) is universally relevant, even though, currently, there is no single conceptual understanding of psychological wellbeing. We begin by supposing that such a conception is possible and coherent, and label that construct as “PWB”. We seek to identify factors that can be manipulated to improve PWB and PWB markers to detect changes in PWB levels. A widely used definition considers PWB as the combination of feeling good and functioning effectively [1,2]. Another widespread concept of PWB is described by the six-dimensional model proposed by Ryff [3]. The model includes, as dimensions of wellbeing, positive relations, autonomy, environmental mastery, personal growth, purpose in life, and self-acceptance. Some researchers distinguish PWB from subjective wellbeing (SWB). SWB refers to people’s self-reported or experienced well-being as combination of life satisfaction, high levels of positive affect, and low levels of negative affect [4]. PWB and SWB are two distinct but directly related concepts [5], which separately or jointly are used by researchers to determine the individuals’ levels of wellbeing. These concepts prepare the grounds for discussions and further investigations on features and measures affecting changes in PWB. In this paper following the definition of mental health provided by the World Health Organization (WHO), PWB is defined as *“a state of wellbeing in which the individual realizes his or her own abilities, can cope with the normal stresses of life, can work productively and fruitfully, and is able to make a contribution to his or her community”* [6].

The World Health Organization (WHO) consider health “A state of complete physical, mental and social wellbeing and not merely the absence of disease or infirmity”, hence “mental health promotion involves actions that improve psychological wellbeing” [6]. PWB levels are directly associated with mental health [7-9] and reliable predictors of physical and mental disorders [10,11]. People with high levels of PWB suffer fewer illnesses, have an increased life expectancy, and engage themselves in healthier behaviors [10,11]. Low levels of PWB are associated with several mental disorders such as depression,

anxiety, stress, mood disorders, eating disorders, personality, and sleep disorders [12-14]. These disorders pose considerable burdens on public health care centers with undesirable costs for individuals, families, and societies. Mental disorders have negative effects not only on patients but also on their families, their social-and work-related environments, and social care costs [15]. Relationships between economic factors and mental disorders have been reported to impact the economy of societies in terms of health care, welfare and lost productivity [16,15]. The costs of mental illnesses for the European Community were estimated to be more than €600 billion per year in 2015 [17]. In the United States, the National Institute of Mental Health estimated that in 2019, 20.6% of all US adults were suffering a mental illness [18,19], and the Lancet Commission on global mental health estimated that the world cost of mental illness would be about US\$16 trillion over the period 2010-2030 [20]. This increasing economic burden on society, globally, associated with mental disorders makes extremely relevant measurements of PWB levels, since their decline is directly associated with mental disorders: it is vital then to seek and identify physiological, psychological and affective variables able to provide indications on individuals' PWB levels. None of current identified PWB factor dominate as "gold standard" [2], and all the existing ones have their own advantages and limitations. Currently, the most widespread tool for detecting PWB levels is by administering questionnaires. The most widely used are the Psychological General Well Being Index [160], the Warwick-Edinburgh Mental Wellbeing Scale [161], Ryff's Psychological WellBeing Scales [3]). However, PWB levels, are time-varying and strongly affected by individuals' dynamic emotional states [21,22], raising the need to identify dynamic measures for PWB levels. This paper intends to report on current PWB measures, discuss their advantages and drawbacks, unifying for the first time, to our knowledge, what have been identified as affecting, therapeutic and detecting features. of PWB. We will discuss on qualities that have been shown to interact with PWB levels, depending on the measurement used (identifying these as "affecting features"). We highlight

the measurable qualities over which individuals may have some levels of conscious influences on PWB (discussing these as “therapeutic features”), and distinguish those from qualities that show correlation with PWB that appear to be at best only indirectly amenable to influence it (naming all these “detecting features”). Our paper thus provides a comprehensive review of PWB detection issues. By reporting on different PWB measures, we open the possibility of cross-calibration across modalities, thereby increasing the accuracy and reliability of PWB level estimates. We see this three-part classification of PWB measures as providing a conceptualization of the literature that both enhances the literature and offers didactic value. The paper provides a first inclusive literature review useful in educational courses to assist novice learners in the understanding of PWB multifaceted literature and carry out comparative experimental evaluations of different PWB features. Finally, our analysis may contribute to guide the choice of new approaches investigating on accurately detection of PWB levels.

This is done by identifying currently published studies (between 2009-2021), which introduce the PWB theoretical framework along with the three categories of features (affecting, therapeutics, and detecting features) that deserved to be considered to enhance the accuracy and reliability of estimating PWB levels.

### **Theoretical framework**

The theoretical framework that we adopt in analyzing research into PWB presupposes that PWB is a mental equilibrium as an ideal but that as there are many dimensions along which such an equilibrium may be disrupted, there is a partial ordering of states of PWB that amount to greater or lesser PWB. Because the dimensions are in some cases independent and in other cases overlapping, measurements of PWB give results that both depend upon the dimension of operationalized assessment and, yet, is not deterministic in relation to any single dimension. That is, for example, greater PWB may be expected with greater states of physical

fitness, but it is not unexpected to find individuals in great states of physical fitness and low states of PWB, and vice versa. Dimensions that contribute to PWB may be analyzed with respect to salient oppositions: (human) internal vs. external, mental vs. physical, individual vs. social, local vs. distal, etc. Within these oppositions and their overlapping aspects, further contrasts are, of course, also germane. For example, within the internal, physical dimension there are natural contrasts that arise according to degree of health in the brain and nervous system or in the muscle and skeleton system. The level of description of the theoretical framework which understands PWB as commensurate with equilibrium is essentially the same that Galen used in describing general health as balance [162] A more detailed specification of Galen's framework involves a distinction between hygiene and therapeutics, where “hygiene” is about maintaining a state (of health) and “therapeutics” addresses changing a state (towards improved health). The corresponding more detailed view of the framework that we adopt distinguishes affecting features, therapeutic features and detection features of PWB. Affecting features are those which do not have a causal influence on levels of PWB, but which provide dimensions along which significant differences in PWB may be seen, especially in combination with other features (e.g. gender combined with regional economic stability). Therapeutic features are those aspects of PWB that are amenable to conscious “exercise” in maintaining a level of PWB or changing state towards improving levels of PWB. Detection features are those which are diagnostic of levels of PWB, but which are not necessarily amenable to conscious control (such as EEG patterns).

Because of the multi-dimensional nature of PWB, like that of general health, it is not clear that a state of perfect PWB is actually attainable, even though it is part of popular discourse to refer to such ideal states. Notably, this generally happens to highlight contrasts with ideal states. It is useful to reflect on the respective transparency of general health and PWB to introspective evaluation. While both are somewhat transparent, it appears rather more likely that someone who has been feeling good healthy may be convinced by an expert

that they have a very serious medical condition that has not yet impinged on the individual's consciousness than that someone who feels to be in good PWB can be convinced by a professional that they are not in a state of good PWB. Divergences from high levels of PWB that are not available to individual introspection seem to be socially determined – whether someone is happy in association with being delusional requires independent judges of the delusional states. Nonetheless, the transparency of these states and general methods of making precise pre-theoretic notions associated with scientific concepts makes self-perception of PWB the starting point for any analysis of PWB. Thus, measures of operationalized dimensions of PWB are generally understood with reference to questionnaire data.

We understand this theoretical framework to provide a unifying approach to specific theoretical models of PWB. For example, one six-factor model emphasizes [23]: autonomy, environmental mastery, personal growth, positive relations with others, purpose in life, self-acceptance. These factors can be seen to invoke the contrasts internal and external physical states as well as individual and social states. Similarly, the specific factors that result from independent exploration of variables [24] also invoke such contrasts: the first major factor there encompasses “general psychological well-being” [24, p. 40] and includes components of affect, cognition, behaviour, self-concept, interpersonal relationships, absence general symptoms of mental disorder. These, too, show contrasts in internal and external conditions. Stepping back from specific theoretical models within a theoretical framework encourages exploration and cataloguing of the wider range of specific qualities that have been found to impinge on PWB, we note that some of these will be seen as affecting features, some as therapeutic features, some as detection features. Mindful of this theoretical framework and the theoretical distinctions we have addressed, we provide a review of recent and relevant literature that addresses features of PWB.

## **Methods**

This paper discussed academic results (e.g. reported in original articles and dissertations) focusing on behavioral, psychological, social and physical PWB features and mental disorders associated with low PWB level. The proposed investigation started on February 2019 and was concluded at the first submission date of the current paper. The studies considered have been published from 2009 to 2020. Google scholar was used for the article searching process. The combination of terms from the first group (psychological wellbeing; subjective wellbeing, mental health, depression, anxiety) and filtered by a second group (physical activity, sleep patterns, sleep difficulties, insomnia, hypersomnia, sleep problems, body language, gestures, body movements, facial expressions, Social interactions, Facebook, social networks, demographic variables, social isolation, creative activities, art, gender, age, marital status, education, income, residency, behavioral patterns, character strength, EEG signals, brain activity, speech patterns, speech, acoustic features, prosodic features, linguistic features, cortisol, chronic physical conditions, body mass index) were used for the searching process.

Research using only terms of the first group retrieved, as expected, a high number of articles (18,800 articles). These were reduced to 173 studies when the other terms were included. In addition, from the 173 paper selected were excluded all papers published before 2009, not written in English, with missing data, identified bias, and dealing with PWB features that would be not included into the three identified categories, i.e. affecting, therapeutic and detecting features. This reduced the discussed papers to 135,

## **Results**

### **Behavioral PWB features**

Patterns of behavioral features or their abrupt change can be a measure of PWB variations' level. In this section the following five behavioral features are considered: physical activity and sleep patterns.

#### *Physical activity*



There is evidence that different sorts of physical activity (PA) have a positive correlation with individuals' PWB. It has been shown that activities such as endurance and gym training improve subjective health, and moderate activities such as walking and ball games are positively correlated with emotional wellbeing [25]. The environment where physical activities are undertaken affects the obtained health benefits. Lawton and colleagues [26] showed that regular outdoor physical activities produce "higher levels of wellbeing and lower levels of trait anxiety" (p. 8) than activities undertaken indoor. Wiese and colleagues [27] in a meta-analysis including 27 studies reported correlational relationships and positive effects of physical activities during leisure time on SWB.

Six weeks or more of physical activities related to endurance, muscle strengthening, and resistance exercises, such as aerobic exercises have been proved to reduce anxiety, depression, mood disturbance and improve life satisfaction [28]. PA's positive impact on subjective wellbeing and health was proved to be effective for children [29], adults [30], elders [31] and clinical samples [32-34]. Several studies demonstrate evidence that mild physical activities are mostly beneficial for women for distress reduction purposes, while intense physical activities are of more benefit for men [35]. Therefore, positive relationships between PA and subjective wellbeing are strongly affected by gender differences, types of preferred sports (personally chosen by men and women) and gender responses to stress [36].

Some studies have investigated the relationship between changes in PA over time with physical and mental health functioning. Holstila and colleagues [37] had shown that mental health and physical functioning improve with increased physical activities and decline independently from the intensity of the undertaken PA. Panza and colleagues [38] further supported these results showing that subjective wellbeing is low in samples undertaking sedentary behaviors and that the intensity of the undertaken PA may affect differently but always positively the three important domains (psychological wellbeing (PWB), depression, pain severity) that measure subjective wellbeing. Finally, benefits derived from PA are

affected by its volume and context, particularly among the young. Doré and colleagues [39] showed that increased PA in leisure time is negatively associated with mental disorders such as depression and anxiety among post-secondary school students. PA carried out in informal and/or sport teams reduce loneliness and produce better results in terms of mental health functioning and mood disorders than PA undertaken in isolation. These results were further supported by Andersen and colleagues [40] who proved that their implementation is “more efficient in promoting health and ensuring exercise participation and continuation than individual sport”, provided precautions are taken to account for the competitive nature of team sports [40, p. 1].

Despite the numerous studies investigating relationships between PWB and PA, a unifying relationship is still missing. Different PA have various characteristics (outdoor or indoor; social or solitary; more or less intensive; type of training etc.) and different PA are related to different psychological benefits [25]. Longitudinal associations remain unclear and debatable given that most of the current studies either associate PA with current level of PWB or otherwise longitudinal associations were reported only for specific age groups such as middle-aged and elders [25,41,42].

#### *Sleep patterns*

Poor sleep and/or insomnia have a significant negative effect on health and wellbeing [43,44]. Sleep problems are often associated with mental health problems [45,46]. When lasting one year or more, sleep problems significantly increase the risk of developing mental disorders such as bipolar and anxiety disorders, suicidal ideation, and especially depression [47]. A substantial number of studies report that sleep problems lasting 12 months or longer are significantly correlated with the onset of severe depressive disorders [48-51] and anxiety [48,52] in non-clinical samples of adults. In addition to causing mental health problems, poor sleep, insomnia, but also hypersomnia is associated with depression [53], it has been shown that, among depressed patients about 15–35% suffer of hypersomnia [54]. However, the

association between depression and hypersomnia need to be furtherly investigated, since, to date, hypersomnia estimates have been based on single questionnaires' responses, neglecting anamnesis on night sleep quality [53]. Nevertheless, not only insomnia and hypersomnia have a negative effect on good level of PWB, they have also been tied to bedtime attitudes. Zhang and colleagues [55] reported that later bedtime (after 22:30) and less than 7 hours of sleep are associated with the definitions of "inadequate quality of sleep" and this condition increases the likelihood of developing anxiety, mood and behavior disorders, suicidal intentions and other mental disorders. Additionally, there is evidence that continuous sleep disturbances (such as an increase of sleep latency, elevated number of intermittent awakenings, and early morning awakenings) also arouse anxiety and depressive disorders [56,54]. The severity of these disorders may vary according to which sleep phases (wake, sleep stage 1, sleep Stage 2, slow-wave sleep, REM sleep) are affected. Baglioni and colleagues [56] reported that anxious and depressed patients have shortened slow-wave sleep, with no changes in the other sleep phases. However, currently, there is not a clear evidence on which sleep phase can be associated with and be predictive of mental disorders [57].

### **Social PWB features**

#### *Body language*

A person's emotional condition and feelings are reflected in their gestures and facial expressions [58]. Facial expressions and body movements are non-verbal ways of communication [59]. Data suggest that body language accounts of more than 60% of meaningful communication [60,61]. Canales and colleagues [62] demonstrated that body movements of depressed patients' (major depressive disorder) are significantly different from those of a control group, with depressed patients showing increased head flexion and thoracic kyphosis, left pelvic retroversion and abduction of the left scapula, and significant differences in shoulders' positions. However, several studies highlighted that to give a value to these differences it is important pay attention to context in which body movements are made. Body

language analyses must be performed on selected groups of movements rather than be focused on deriving actions [60].

### *Facial expressions*

In addition to the body language, facial expressions carry significant information in the detection of states of PWB. There is a 35% likelihood to increase the success of interactional exchanges when messages are simultaneously read from both face and body (e. g. [63]). A significant decrease in facial activity in general is related to depression, whereas increased facial activity is associated with SWB improvement [64]. Investigating separate face features e.g. eye movement, smile etc. also contribute to PWB level detection. There are data showing that socially anxious patients hold their eyes longer on threatening [65-67] and smiling faces [65]. Additionally, Wieser and colleagues [68], using virtual reality, demonstrated that women with social anxiety compared to a control group increasingly avoid direct gaze of men (among female students recruited as participants in a German university, n=162). Furthermore, Girard and colleagues [69] reported more contempt and less smiles on depressed patients' faces, with smiling often associated with contempt rather than happiness. However, it is also known that there are different categories of smiles performing various social functions, other than reflecting feelings (e. g. [70,71]). Attributing depressive states to individuals not expressing smiling faces can be debated and more investigations are required to assess this issue [72]. Finally, there is evidence in the academic literature that temporal facial dynamics provide more information and more useful for depression detection than using static facial expression information only [64].

### *Social interactions*

There is data that perceived emotional support and perceived negative interactions have some effect on a person's PWB. In a systematic review, Santini and colleagues [73] investigated 35 studies which focused on the association between social support variables and depression; a significant association was established in 32 over the 35 studies and it was

concluded that high level of perceived emotional support is helpful in preventing depression, while low level are linked to the onset or presence of depression. However, 5 of the 35 studies focusing on both perceived emotional support and perceived negative interactions, reported mixed or contradictory results. Moreover, in that same review 7 studies were investigating on perceptual differences in receiving emotional support and/or perceiving negative interactions either from family members or friends. Five of these studies reported a significant effect from both sources of social support to predict depressive states. However, in the remaining 2 studies effects from friends' support were not strongly established

The size of social networks can be a significant predictor of PWB as well. In many studies, it has been shown that large established social networks prevent older adults from being affected by depression [74-80]. However, it was also shown that older adults' social isolation is not a predictor of depressive symptoms (e.g. [81]). Chao [75] suggested that it is necessary a combination of diverse social networks, appropriately sized (such as 25–50% family and 50–75% friends) to effectively reduce individuals' isolation. However, also the quality of the network (lack of connection with depressed persons) is important. Rosenquist and colleagues [82] demonstrated a positive correlation between individuals own depressive states and depressive conditions of their friends and neighbors.

Cacioppo and colleagues [83] claimed that loneliness is another significant predictor of depression and is independent from demographic variables, objective social isolation and received/perceived social support. The evidence comes from their 5-year longitudinal study proving that both the loneliness and a rather small social network are significant predictors of depressive symptoms. Chan and colleagues [74] reported that this association is more effective for women. However, Sonnenberg and colleagues [80] concluded that men demonstrate higher rates of depression, related with loneliness, compared with women. Despite the evidence above, Santini and colleagues [73], in a systematic review including 51

studies, reported only a little evidence for the association between social connectedness and depression.

Online social interaction is becoming a widespread and important part of peoples' interactional exchanges. The most popular and widely used online social networks in the world is Facebook [84]. There are controversial data about the effect of online social networks to PWB. Some researchers concluded that intensive online interactions can be associated with positive effects on PWB level [85,84]. Others researchers reported opposite effects showing that intensive online interactions can lead to depression and loneliness [86,87], and others showed that both effects can occur [88]. Hu and colleagues [88] investigated students' Facebook intensity of use and its association with PWB levels showing that there can be observed either positive or negative effects on PWB level depending on students' extroversion/introversion characters. Positive effects in using intensively Facebook were more significant for introverted individuals. Finally, other researchers attributed to social networks users' motivations the arousal of positive or negative individuals' reactions, and showed that using Facebook for maintaining real-life friendships has a positive effect on PWB, while using it for establishing new connections (e.g., making new friends) is associated with negative effects on PWB [89].

### *Creative activities*

There is some evidence that arts, in general, can improve health and PWB level not only of non-clinical adults and elders but also clinical ones. Grossi and colleagues [90] investigated 1,500 adults and established that opportunities for cultural participation is the second most important determinant of PWB (after absence or presence of diseases). In more recent study, Davies and colleagues [91] investigated the association between recreational arts engagement and PWB level in 702 adults. They concluded that 100 hours/year or more arts' engagements have a significant positive effect on PWB level. Todd and colleagues [92] and Thomson and colleagues [93] showed a positive effect of museum-based activities on older

adults' wellbeing. A project designed by Colbert and colleagues [94] engaged 12 individuals with psychosis in 4 galleries' visiting sessions and 10 out of 12 participating to all sessions reported that "the project had contributed to their wellbeing".

Despite these proofs attributing to creative activities significant positive effects on PWB level, some researchers suggested more investigations objecting on the complexity to isolate these positive effects of creative arts from other variables (e.g. [95]). Leckey [95] in a review including 11 studies, showed a protective effect on PWB level of creative activities. However, they underlined the difficulty "to make comparisons of the [reported] studies being evaluative in nature and untaken within local projects, therefore, lacking in generalization" [95, p. 1].

Several authors maintained that since during creative activities, people evaluate artworks (e.g., sculpture, music, visual arts, etc.) which produce both certain emotions and engage them into in an aesthetic experience, it is trivial to observe an upsurge of PWB level (e.g. [96-98]). However, the review proposed by Mastandrea and colleagues [97] investigating the association between aesthetic experience and PWB level concluded that this positive association must be furtherly investigated to overcome the limitations of the proposed studies.

### **Demographic PWB features**

Demographic features are features that allow to categorize people. These features are age, gender, marital status, education, incomes, and residency. Their effects on PWB level are easily measurable.

#### *Gender and age*

There is statistical evidence about differences between gender, age and individuals' PWB. Several authors suggested that age and gender are main factors associated with life satisfaction and directly correlated with PWB level (e.g. [99]). In general, it has been shown by numerous studies that females PWB level are lower than males ones (e.g. [90,100-103]). In addition, there are data showing that PWB levels decrease with age [100,99,102], and this

decrease is significantly higher in female rather than male individuals [103]. It has also been reported that this decrease is observed in the age range between 55 and 64 years, and then it stays stable with no considerable sex-related differences after this age [103]. These data deserve further investigation, since contradictory results have been also reported. Particularly, Lincoln and colleagues [101], in a study involving respondents from different nationality (African Americans, non-Hispanic whites, blacks of Caribbean descent) observed lower PWB level in young rather than older adults. Finally, several researchers questioned the significance of ageing effects on PWB level suggesting that it can be caused, at least in part, by methodological artifacts. Specifically, Springer and colleagues [104] reported that “longitudinal age variations never accounting for more than 4%” [of PWB level’ variations] and “far greater variations within ages or periods than between subscales across age or time” have been observed.

#### *Marital status*

Family relationships in general, and marital status in particular, are enduring and consequential variables of health and positive PWB level. There is evidence that married participants demonstrated higher PWB level than single and divorced respondents (e.g. [101,103,105]). However, there is data that correlation between marital status and PWB changes over time. This suggestion was made by Cao and colleagues [106] in a 20-year longitudinal study focused on the association between marital status of subjects affected by spinal cord injuries and their SWB level. They established that married/partnered participants had the highest SWB levels at the start of the study, but that this decreased with time. The SWB level of the single did not increase for those maintaining that status. In addition, Hughes and Waite [107] investigating marriage’s records from older adults noticed that PWB benefits of the remarriage may not be so large as benefits observed at the first marriage and negative effects of past marital disruptions correlate significantly with years later observed health’s status worsenings and the development of depressive symptoms.



### *Education, income, residency*

Level of education, income and residency may have significant impact on individuals positive PWB level and general health status. In a systematic literature review by Read and colleagues [108] 71 studies which investigated the effect of different socio-economic factors on subjective health and wellbeing among older people were included. An association between education, adequacy of incomes and self-rated health, which was considered in 32 of 71 studies, was established in 28 out of 32. 7 studies out of 71 investigated an association between self-rated adequacy of income and self-rated health and all of 7 reported the association. In addition, an association between life satisfaction and income, which was examined in 3 out of 71 studies, was established in 2 studies. An association between life satisfaction and education, was considered in 5 out of 71 studies and 3 investigations out of 5 reported the association. There is evidence that high education and high incomes correlate positively with high PWB level and good mental health (e.g. [100, 109, 101, 103]), and even with improving psychological adjustments (e.g. [99]). High personal incomes have an improving effect on adults' PWB level (e.g. [101, 103]) even though adolescents' own perceptions of family's economic positions relate more significantly than the realistic incomes of their families with their mental health status [110].

There are no clear results connecting residency's impact on PWB level. Sun and colleagues [103] investigated associating between residency and SWB for 8,000 Chinese's respondents. They reported that villagers predominantly have higher level of SWB than city residents, independently from their socioeconomic and subjective health status. Nevertheless, Requena [111], which reported data from 56,835 respondents from 29 different countries, observed that villagers have higher SWB level than city residents only in developed, wealthier countries. Garrett and colleagues [112] collected residency's data from 25,963 English adults and reported positive associations between living closer to the coast and respondents' mental health status. City residents living near coastal settings (within a radius of 1 km) have less

mental health problems than citizens living more than 50 km away. However, the association was significant only among low-earning respondents, living less than 5 km far from the coast. The World Happiness Report [113], investigating differences on happiness levels of urban and rural residents in 150 countries, supported the conclusions of the above-mentioned studies reporting that, in general, urban residents are showing higher levels of happiness than city residents.

#### Psychological PWB features

Personal psychological characteristics have an impact on our behavioral patterns, decision-makings and individuals' mental wellbeing and PWB level. In the following are discussed psychological features which have been reported to affect PWB level.

#### *Character strength*

Character strengths are defined as “personality traits that are positively valued, and represent different routes to the superordinate virtues” [114, p. 1]. Character strengths were introduced by Peterson and Seligman [115] as positive personality traits that can contribute to an individual's good life achievements. 24 character strengths have been identified; among those it is possible to find appreciation of beauty and excellence, hope (optimism), humor (playfulness), spirituality, courage. Höfer and colleagues [114] reported positive correlations among PWB level, mental wellbeing, and character strengths. Hausler and colleagues [116] reported correlations, from high to moderate, of character strengths as hope, zest, gratitude, curiosity and love correlations with PWB and SWB level. Similar correlations were reported by Höfer and colleagues [114] with character strengths such as zest, hope, curiosity and love, and by Wagner and colleagues [117] which reported that perspective, persistence and zest are the best predictors of wellbeing.

Further support of the positive correlations between character strengths use and life satisfaction among undergraduate students were reported by Allan and Duffy [118] and Douglass and Duffy [119]. The first investigation included one more variable which was not

examined in studies described above, which is calling. Allan and Duffy [118] defined calling as “careers that are personally meaningful and work toward the greater good” (p. 3). They established that individuals with low in calling and high level of signature strengths (the authors summed participants’ scores for their top 5 character strengths to receive a signature strengths level score, according to the method of Littman-Ovadia [120] demonstrated the significant association between strengths use and life satisfaction. The second investigation also confirmed that increased level of self-esteem in students was partially due to strengths’ use connected with life satisfaction. Additionally, Douglass and Duffy [119] investigated the association between strengths’ use and life satisfaction by studying the potential mediating effect of self-esteem and potential moderating effect of positive affect. The authors concluded that strengths use was associated with elevated levels of life satisfaction.

Other personality traits that may contribute to positive PWB level are individuals’ patterns of behavior, thoughts, and emotions [121]. Saricaoğlu and Arslan [122] found significant positive correlation between all subscales of PWB, according to six-stages Ryff’s model, and self-compassion. The positive correlation between an agreeableness and PWB was identified for 5 PWB subscales except autonomy. Moreira and colleagues [123], while investigating psychobiological model of personality as multidimensional character profiles (self-directedness, cooperativeness and self-transcendence) and wellbeing in adolescents, found that self-directedness was strongly associated with all dimensions of wellbeing, but cooperativeness related to it “only when associated to the elevation of self-directedness and self-transcendence” [123, p. 1]. The researchers concluded that an independent contribution to wellbeing is provided by each character dimension and it depends of the interactions with other dimensions of character and this find for adolescents is consistent with others study results which were focused on adults (e.g. [124, 125]).

Biomarkers of PWB

Physiological features of PWB are: EEG signals, speech patterns, cortisol levels, chronic physical conditions and body mass index.

### *EEG signals*

There is no unanimous consensus on the correlation between EEG signals and PWB level. Klug [126] did not observe relationship between PWB level and frontal alpha wave asymmetry. However, Saeed and colleagues [127] suggested that alpha wave asymmetry (frontal and temporal) can be used as biomarker for stress detecting and classification. Moreover, a support vector machine, based on expert evaluation-based labeling method, is effective for classification of long-term human stress, according the authors' suggestion. This machine, developed by Saeed and colleagues [127], reached up to 85.20% accuracy. Furthermore, the support vector machine, by Sharma and Chopra [128], has reached up to 90.32% accuracy in stress detection by using alpha waves.

There are data that greater relative right-sided brain activity in the medial-frontal region can be a predictor of depressive symptoms a year after the first data collection. Mitchell and Pössel [129] examined and established this association among boys. However, greater relative right-sided activity in the lateral-frontal was not related to depressive symptoms one year later. Moreover, an association between frontal brain activity at baseline and current symptoms of depression was not established. Demerdzieva [130] investigated EEG brain activity in children with anxiety disorder and concluded that these children have decreased theta, alpha and beta activity, especially in central and midline regions [130]. Additionally, a suggestion that there are a limited number of electrode sites, from which clinicians may get useful data for detecting subjects with MDD, has been made by Cook and colleagues [131]. They established that brain oscillatory activity from the midline prefrontal region relates to changed brain activity in MDD subjects. In a review by Newson and Thiagarajan [132], it was concluded that for depression an increase of absolute power for delta and theta bands for both closed and open eyes condition is typical. For instance, Arns

and colleagues [133] demonstrated increased theta power across frontal regions of the brain using the eLORETA source localized signal. However, this study included the largest amount of subjects, comparing with other studies which were included in the review. Moreover, Arns and colleagues [133] used the eLORETA, which is methodologically different from most other studies included in the review. Consequently, those conditions could be a reason of bias of the review results and conclusion. Additionally, in the studies considered in the review, in which researchers failed to find any significant differences across any band, these increases of absolute power were no longer visible (e.g. [131]).

Finally, in many studies, it is noticed that despite accumulated data and evidence that EEG signs are associated with depression and other mental problems, there are inconsistencies in the literature since different researchers use various methodology for investigating (e.g. [134, 135, 132, 136]).

#### *Speech patterns*

Speech features investigations are becoming more widespread mental health variable for study. Cummins and colleagues [137] established that both depression and suicidality, which directly have an impact on PWB level, might lead to some cognitive impairments which are reflected in speech. There are acoustic, prosodic and linguistic features of speech which researchers are investigating. Pauses during speech, reduction in articulatory coordination and respiratory rate are acoustic features which have significant correlations with several mental problems. Speaking rate, the pitch, loudness and energy dynamics are prosodic features of it. Using first-person singular pronouns (FPSP), negative emotion words and positive emotion words are linguistic features which can be related to mental health recognition.

Taguchi and colleagues [138] demonstrated that Mel-frequency cepstral coefficients (MFCC), MFCC2 are substantially different by depressed and control group; MFCC2' group contrasts reflected an energy difference in frequency about 2000–3000 Hz. However, in other

study by Wang and colleagues [139], which used answers on emotional videos for data collection, established that loudness and other MFCC variables such as MFCC5 and MFCC7 significantly differ between groups; this dissimilarity was significant with no regard of emotions and tasks which were involved.

Prosodic features such as total pause time, pause variability, per cent pause time, speech/pause ratio, and speaking rate was recognized by Mundt and colleagues [140] as significant variables for depression detection and for categorizing the severity of symptoms; natural speech and reading were used for data collection. Additionally, Yang and colleagues [141] also suggested that features of vocal prosody could be a considerable contribution to depression detecting. In the study, which investigated both acoustic and prosodic features, it was established that articulation rate, phonation time, speaking rate, pitch, average absolute deviation of energy and MFCC1,6-10 have statistical significance and are reliable features of speech for depression detection [142]. In this study, researchers asked patients from one of the groups (both groups consisted of depressed participants) to suppress anything that they felt would be indicative of their depression and then analyzed and compressed these data. According to the results, despite concealed participants' behavior the variables remained relatively robust. It indicates good potential for building deception-proof automatic depression monitoring systems; however, small sample was used in the study, only 17 participants.

In the meta-analysis by Tølbøll [143], which included 26 studies, which focused on investigating linguistic features of speech related to depression, an association between all these features and depression was demonstrated. Despite proof of frequent usage of FPSP by depressed persons, the positive relation to it was established from small to medium, hence, this feature can be used as a feature for depression detecting but not for identification of depression levels. The feature such as increased usage of negative emotion words by depressed persons in comparison with control samples was confirmed; however, there is a contradictory classification of the effect sizes (Cohen's  $d = 0.72$  and Pearson's  $r = 0.12$ ) which

could have been caused by the possibility of publication bias. The association between decreased usage of positive emotion words and depression was also confirmed. The association was from small to medium (Cohen's  $d = -0.38$  and Pearson's  $r = -0.21$ ). Finally, Tølbøll [143] specified that the variance of results presented in the studies could not be explained by either age or task category and have to further investigation.

### *Cortisol*

Cortisol is a biomarker of hypothalamic pituitary adrenal axis functioning. Researchers are investigating cortisol disbalance in blood, saliva, hair strands and urine and alteration of cortisol level during a day or longer periods. There is a number of studies in which association between higher salivary cortisol level in general and depression were established. Besides a conclusion of the association between higher salivary cortisol level and depression, Dienes and colleagues [144] suggested that not only depressed participants demonstrate is higher diurnal cortisol measures but also participants at risk for depression demonstrate similar cortisol results. Subjects with risk of depression also showed significantly higher waking cortisol levels beside with control subjects. However, the response to the laboratory social stressor was different for these two groups. In addition, significantly higher cortisol during the last 3 months was registered in hair strands of participants with mental health problems [145]. In a review by Staufenbiel and colleagues [146] of 19 studies, it was claimed that in general depression associates with increased hair cortisol, however, anxiety disorders associate with decreased cortisol index. Additionally, concentrations of it increased for bipolar disorder only in patients with a late age of onset. In a review investigating diurnal cortisol slopes by Adam and colleagues [147], the researchers concluded that flatter diurnal cortisol slopes associated with poor mental health in general and with depression and anxiety in particular. However, some other study demonstrated data that only evening salivary cortisol associates with PWB. Stafford and colleagues [148] concluded that every 1 standard deviation increase cortisol in

the evening time was associated with a decrease of PWB level on 0.47 point, according to Warwick Edinburgh Mental Wellbeing Scale.

### *Chronic Physical conditions*

There is no uniform definition of chronic physical conditions (CPC); however, most of authors consider CPC as a recurring, lasting condition, and/or physical consequences of the condition [149]. For instance, Conversano [150] defined CPC as a several persisting lifelong heterogeneous conditions which have strong effects on PWB level. Santos and colleagues [151] investigating relations between CPC of adolescents and PWB concluded that CPC have a significant negative effect on adolescents' PWB if it influences school participation. In addition, most of CPC have an association with suicidal ideation in the total sample, according Scott and colleagues [152]. An association between chronic conditions such as epilepsy, cancer, heart attack, stroke and planned suicidal attempts was established. Chronic conditions as heart attack, stroke, high blood pressure, arthritis, respiratory conditions, chronic headache and other chronic pain have association with suicidal attempts. The risk of suicidal outcomes soars with the increasing of CPC numbers, but this increase is not proportionate. The additional risk is smaller with each additional CPC. However, there was established only 1.0–6.5% of the association between the incidence of depression in Taiwanese patients with metabolic syndrome that significantly lower than in western countries [153]; hence, there can be regional differences of this association. Acceptance of patients their CPC is another dimension which has an effect on PWB. Verhoof and colleagues [154] investigated an association between feeling of acceptance, anxiety and depression in young adults, who have a disability benefit because of a CPC since childhood. The association was established, more acceptance of CPC is related with less anxiety and depression. Additionally, there is some evidence that mental health problems are able to affect the course of CPC and able to cause sequelae and further complications (e.g. [155]). According to a study of Daré



and colleagues [155], there is a 36.6% combined prevalence of mental health problems in CPC patients.

### *Body mass index*

According to WHO in 2016 more than 1,9 billion adults were overweight, in addition, about 650 million of these were obese.<sup>1</sup> A correlation between body mass index (BMI) and mental health problems was established in many studies; however, an effect of the correlation can vary in different groups (age, gender, health status etc).

In the meta-analysis by de Wit and colleagues [156] which studied the relation between obesity and depression in a total of 204,507 adults, the strong relation was established and was more marked among women. In the systematic review and meta-analysis by Luppino and colleagues [157], which included 15 longitudinal studies, the relation between depression and obesity was re-established) Moreover, a reverse association was also established, depression was found to be a predictor of obesity developing. de Wit and colleagues [158] demonstrated that there is a negative effect of both underweight and obesity (U-shaped association) on men and women mental health, in particular, it leads to depression. However, in a study by Linna and colleagues [159], which include 5240 twins in the investigation, inverse U-shaped association between BMI and SWB was established for men and women with lifetime eating disorder only. It was concluded that optimal BIM verifies from 26.1 to 28.9 kg/m<sup>2</sup>.

## **Discussion**

Since the last century, there has been a growing interest in investigating PWB. However, there is still a need to establish a universal, independent measure of PWB without any limitations or with minimal limitations. It will allow introducing this measure to

healthcare system easily for early detection and preventive treatments of low level of PWB; consequently, it will reduce costs of diagnostics and therapy, as well as improve patients' quality of life. There are many limitations for establishing universal measure, such as high cost of equipment, its bulkiness, static evaluating, which does not allow to estimate dynamic changing, the unreliability of measurements and reverse output etc. Additionally, Dejonckheere and colleagues [21] reported another important limitation. New measures for detecting and predicting PWB are being investigated, but not all of the researcher's findings convey unique information. The Dejonckheere study, which investigated existing emotion dynamics measures relating to PWB, established that several of these measures have little added value; they are unable to demonstrate independent relations between affect dynamics and PWB. Therefore, researchers should take added value into consideration studying new measures and verify that their findings provide unique information.

In an effort to develop new universal PWB measure, researchers are using different human features for it. We suggest that the features, which were considered in the paper, could be categorized into three groups: affecting features, features for therapy and detection features. We provide a summary table of the classification of works reviewed here below.

[<<INSERT TABLE NEAR HERE>>](#)

The first group includes features which affect PWB and are not likely to be changed. The features of this group are considered by us as factual, which contribute to PWB level, but could not be used as a main feature of PWB level detection. We suggest that an age, gender, marital status, personal's characteristic, education, income, cortisol, residency, chronic physical conditions could be included to the first group. Interactions among these features have also been noted, for example, some effects of marital status may depend on the culture in which the measurements are made (and this has a residency element).

In the second group we classify features which could be improved relatively easy by people by means of exercising persistent conscious intervention. Consequently, therapists,

based on these features, could develop therapy for improving patient's PWB level. Physical activity, sleep patterns, body mass, creative activities, social interaction are the PWB features of the second group. For instance, according to results of Zhang and colleagues [55], later bedtime and sleep of less than 7 hours have a negative effect on PWB, hence earlier bedtime (before 22:30) and sleep of more than 7 hours may be used as a therapist's recommendation for a patient with a decreased PWB level. A therapist can also recommend patients to reduce communication with friends and neighbors who have been diagnosed with depression, according results of a study by Rosenquist and colleagues [82]. In addition, nutrition changes to achieve the optimal BMI from 26.1 to 28.9kg/m<sup>2</sup> could be recommended by therapists [159].

Detecting features are ones which, as we suggest, could be used as reliable measures for detecting PWB level. We classified EEG signals, speech patterns, body language and facial expression in the third group. According to our knowledge, there are not a lot of studies which investigate these features as specific PWB measures i.e. measures which detect PWB level considering all PWB dimensions, not only absence of depression, anxiety etc. Therefore, this gap has to be investigated in the further studies. While one may decide to exercise or diet, with exercise having an impact upon EEG signals, most people have little direct conscious control over their EEG signals. Thus, detection features are distinct from therapeutic features.

We think that EEG signals and speech patterns are more promising features for PWB level detection than other features from the third group. One of the reasons is that these features hardly can be controlled by a person (there is no way to hide symptoms) hence it makes that features more reliable than body language and facial expression. EEG is one of the most common sources of information for studying brain function. It allows investigating psychological disorders and emotions. This method is simple, safe, non-invasive, low-cost and also relatively comfortable for participants. Moreover, EEG is lightweight, it can be

wireless, and it is becoming more increasingly tolerant to head and body movements, even allowing participants to walk freely. In addition, many medical institutions already have EEG equipment. Based on the above, if relationship between EEG signs and PWB will be clearly established, EEG can widespread be used as a PWB measure at clinic practices in perspective. However, speech patterns have the list of important advantages over EEG signals. Data collection for these pattern investigations can be in the background, in a natural setting by apps for smartphones. It could allow solving several limitations related to patients' trying to hide symptoms and could allow to introduce speech patterns application for PWB detection worldwide. In addition, according to the fact that these features will be detected by smartphone, it enables reduced money and time expenses, since there is no need to buy equipment and visit a laboratory and spend time in there for data collection. Investigation of these features of PWB, EEG signs and speech patterns could allow to spread PWB detection widely with fewer restrictions and not only detect it but also predict.

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### **Conflicts of interest**

The authors individually and jointly declare that there is no conflict of interest.

### **Author contributions**

**Olga Sheveleva:** Data Curation, Investigation, Writing – Original Draft; **Gennaro Cordasco:** Conceptualization, Supervision, Writing – Review and Editing; **Carl Vogel:** Conceptualization, Writing-Review and Editing; **Anna Esposito:** Funding acquisition, Conceptualization, Supervision, Writing – Review and Editing.

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