MHQ: Constructing an aggregate metric of mental wellbeing

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ABSTRACT

According to the World Health Organization (WHO), mental health is "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". Any national or global metric of mental wellbeing therefore needs to reflect not only how people are feeling, but also how well they are functioning in life across a range of cognitive, social, emotional and physical dimensions. However, existing metrics typically focus on either negative symptoms or conversely, feelings of happiness or life satisfaction, rather than functioning, or indirectly infer wellbeing from a selection of social and economic factors. Here we present the Mental Health Quotient, or MHQ, a metric of mental wellbeing that comprehensively captures both feeling and functioning, and that is based on this WHO definition. We describe the 47-item assessment and the life impact rating scale on which the MHQ metric is based, as well as the rationale behind each step of the nonlinear algorithm used to construct the MHQ metric. We then demonstrate that this results in a linear relationship between the MHQ metric and productive life function where movement on the scale from any point or in any direction relates to an equivalent shift in productive ability at the population level, a relationship that is not borne out using simple sum scores. We further show that this relationship is the same across all age groups. Finally, we demonstrate the potential for the types of insights that the MHQ metric can provide, offering examples from the Global Mind Project, an initiative that aims to track and understand our evolving mental wellbeing, and since 2020 has collected responses from over 1 million individuals across 140+ countries.

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1. INTRODUCTION

The concept of mental wellbeing is underpinned by both feeling and functioning well [1–4]. In this sense, wellbeing is not the same as happiness or life satisfaction which are often framed in the context of "feeling well" without fully considering a person's ability to function well in life, such as their ability to form meaningful relationships, show resilience in the face of adversity or work productively towards goals. In addition, mental wellbeing is not simply the absence of ill (mental) health but also reflects the ability to positively thrive in life. Indeed, according to the World Health Organization (WHO), mental health is "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" [5]. Mental wellbeing is therefore a multifaceted concept that reflects a broad landscape of emotional, cognitive, social and physical feelings and functions that have an impact on everyday life. Any metric aligning with this definition must therefore be constructed from a comprehensive evaluation of subjective mental experience and functioning. In addition, any appropriate metric should also reflect this continuum from distress and the inability to function, through to the ability to thrive and function to one's full potential.

Although several global and national metrics of wellbeing and happiness exist (e.g. Gallups's World Happiness Report [6]; OECD's Better Life Index [7]; Bhutan's Gross National Happiness [8], as well as others [3]), these either rely on a simple rating of life satisfaction (a measure of 'feeling' that can typically be interpreted with respect to one's satisfaction with circumstances rather than mental feeling and function), do not span the full spectrum of mental functioning, or indirectly infer wellbeing from a set of social factors such as income, education and healthcare which have been shown to relate to wellbeing or are commonly assumed to do so. Currently, therefore, to our knowledge, there are no metrics of mental wellbeing that comprehensively integrate both mental feeling and function along the various dimensions required for a productive life that can be used effectively for population measurement. Such a metric is important as the functional wellbeing of mind is fundamental for long term human success. Measuring and understanding population mental wellbeing independently of social and economic factors, rather than inferred from them, is therefore critical in giving an accurate and real-time view of how people are faring and enables a deeper understanding of how changing social and environmental factors impact different facets of mental wellbeing. For instance, it could help explain why Finland has one of the highest suicide rates in western and northern Europe at 13 per 1000 [9] despite consistently having the highest ranking for life satisfaction, a term that is often interpreted and used interchangeably with happiness [6].

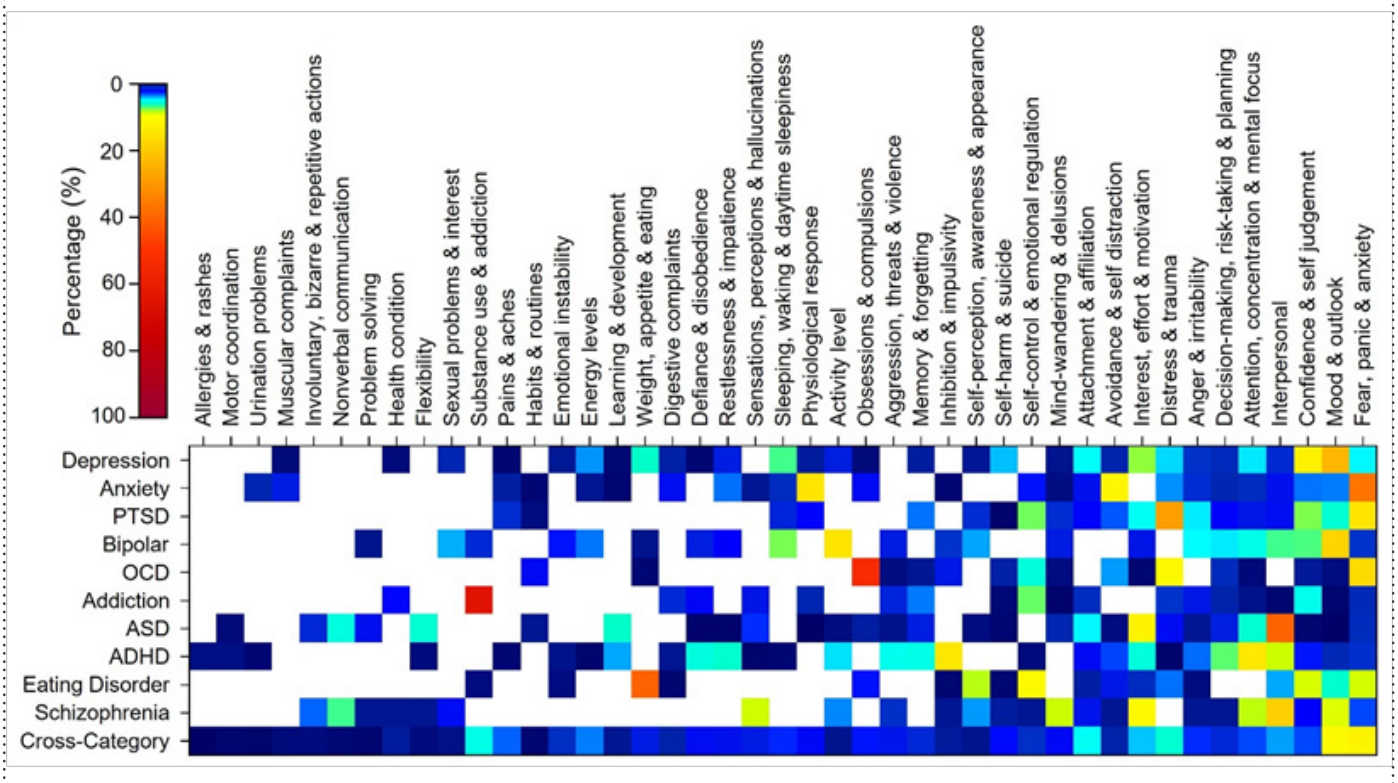
Having a comprehensive assessment and associated metric that captures recorded, rather than inferred, mental wellbeing is also particularly important in the context of current societal trends where mental wellbeing has declined to alarming levels over the past decade particularly in younger generations [10,11]. Such an assessment and metric can enable understanding of evolving trends and how various life experience, lifestyle and environmental factors differentially impact specific aspects of mental function. This can be used by researchers, clinicians, public health professionals and policy makers to guide the development and implementation of preventative strategies and solutions to improve mental wellbeing and monitor their magnitude of impact. Such approaches can also be implemented at various levels from governments to organizations and establishments such as schools, universities and companies in the context of their students, employees and citizens.

In this paper we describe a new metric, the Mental Health Quotient or MHQ that is based on the WHO definition [5], describing how it is constructed to provide a comprehensive readout of mental wellbeing that comprehensively captures both feeling and function and relates linearly to measures of productivity.

1.1. Constructing a metric of mental feeling and function

The first step in developing an appropriate metric of mental wellbeing is ensuring it is based on an assessment that captures the full landscape of mental feeling and function. A large number of measurement tools have been previously developed to assess mental health and wellbeing. Within the clinical domain, these typically focus on symptoms of individual disorders, or take a cross-disorder perspective. We have previously analyzed 126 commonly used assessments spanning 10 different mental health disorders [depression, anxiety, bipolar disorder, ADHD, post-traumatic stress disorder (PTSD), obsessive-compulsive disorder (OCD), addiction, schizophrenia, eating disorder, and autism spectrum disorder (ASD)], together with cross-disorder tools, and categorized 10,154 questions according to their functional and symptomatic characteristics [12]. This gave rise to an initial list of 170 different subcategories of mental health symptoms and functions that were subsequently consolidated into a set of 43 categories by grouping together semantically similar subcategories in order to be as parsimonious as possible but yet comprehensive. A subsequent review of these categories in the context of each of the 126 assessments revealed a great deal of redundancy of symptoms across disorder categories such that aggregating multiple assessments into one would have substantial repetition. Furthermore none comprehensively captured all 43 categories and therefore were individually insufficient at assessing the full landscape of mental symptoms (Figure 1); see [12] for more details.

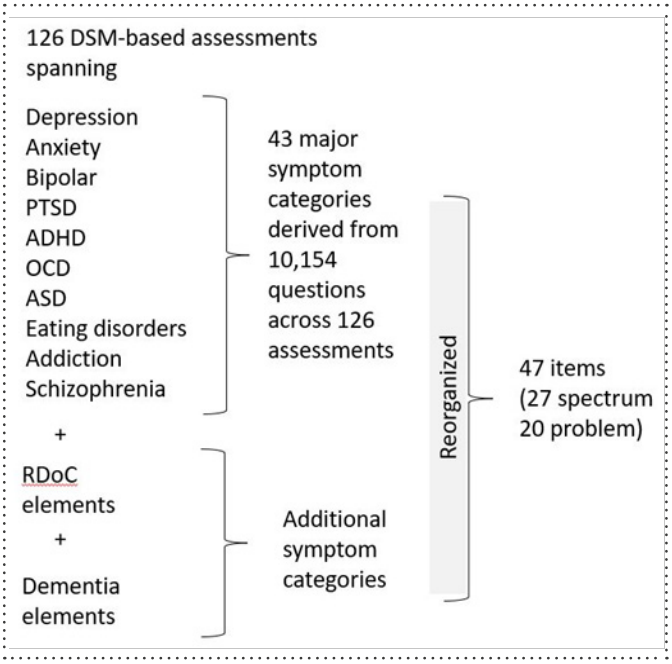
Figure 1 - *PROPORTION (%) OF QUESTIONS FROM EACH OF THE 43 SYMPTOM CATEGORIES FOR EACH DISORDER (AVERAGED ACROSS ASSESSMENT TOOLS) AND FOR CROSS DISORDER TOOLS. REPRODUCED FROM* [12]



Within the domain of psychological wellbeing, numerous assessments also exist, e.g., [13–15]. These include questions that span a wide range of topics from spiritual and financial wellbeing through to happiness and life purpose. However, a review of 99 wellbeing tools revealed that they are also highly heterogenous and there was "little unanimous agreement on how well-being should be measured" [16]. In addition, none comprehensively captures the full landscape of mental functioning that includes both symptoms of mental distress as well as functions which could be considered assets to performance and life outcomes.

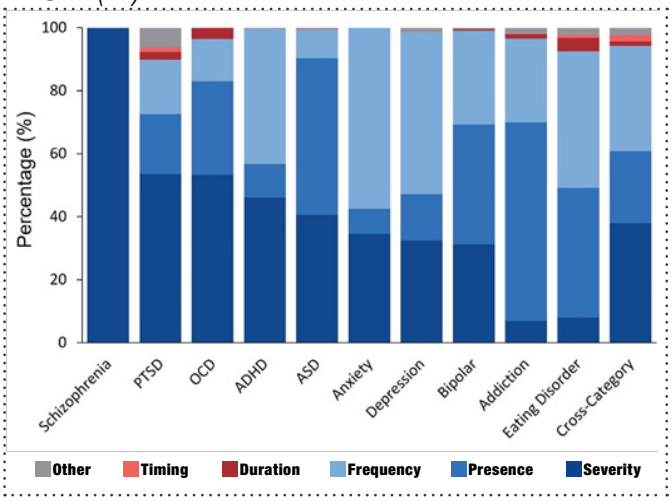
To overcome these limitations with existing measures, we therefore developed a new assessment that comprehensively captures all dimensions of mental function and reflects life experience and consequence, from which an aggregate metric of mental wellbeing could be constructed (Newson et al., 2022; Newson & Thiagarajan, 2020). In brief, the 43 categories identified in our previous analysis of 126 mental health assessment tools [12] were subsequently reviewed in the context of other functional frameworks from neuroscience, (e.g., Research Domain Criteria, RDoC [17]) and neurology (e.g., dementia) and rearranged into a set of 47 semantically distinct items (Figure 2) [18].

Figure 2:
DIAGRAM ILLUSTRATING THE METHOD OF DEVELOPMENT OF THE MENTAL HEALTH QUOTIENT



A second criteria of a comprehensive assessment that reflects life consequence is that items should be assessed, or rated, in a way that doesn't just capture "symptoms" or when something has gone "wrong" with a function, but also the positive aspects of mental function. In addition, ratings should also reflect the overall life consequence or impact of an item on a person's ability to function and be productive in life. Existing mental health assessments typically use a variety of scales that include the presence or absence of symptoms or estimates of their frequency, severity, or duration and can vary even within assessments of the same disorder grouping (Figure 3) [12]. However, each only provides a unidimensional perspective of symptomatic experience that may not be equivalent in their life impact. For example, experiencing a symptom frequently but at a very low level of severity could have a lesser life impact than experiencing it rarely but with crippling severity. The MHQ assessment therefore evaluates these 47 items using a life impact scale based on one's current perception that reflects both negative and positive aspects of mental function, captures an integrated perspective of frequency, severity, and duration of any challenge, and provides a standardized metric of functional consequence that does not rely on recalled experience that can be difficult for a respondent to remember.

Figure 3:
COMPARATIVE PROPORTION OF QUESTIONS WITHIN EACH DISORDER AND FOR CROSS-DISORDER TOOLS (AVERAGED ACROSS ASSESSMENT TOOLS) BY SYMPTOM ASPECTS: SEVERITY (DARK BLUE), PRESENCE (MID BLUE), FREQUENCY (LIGHT BLUE), DURATION (DARK RED), TIMING (LIGHT RED). REPRODUCED FROM (12)

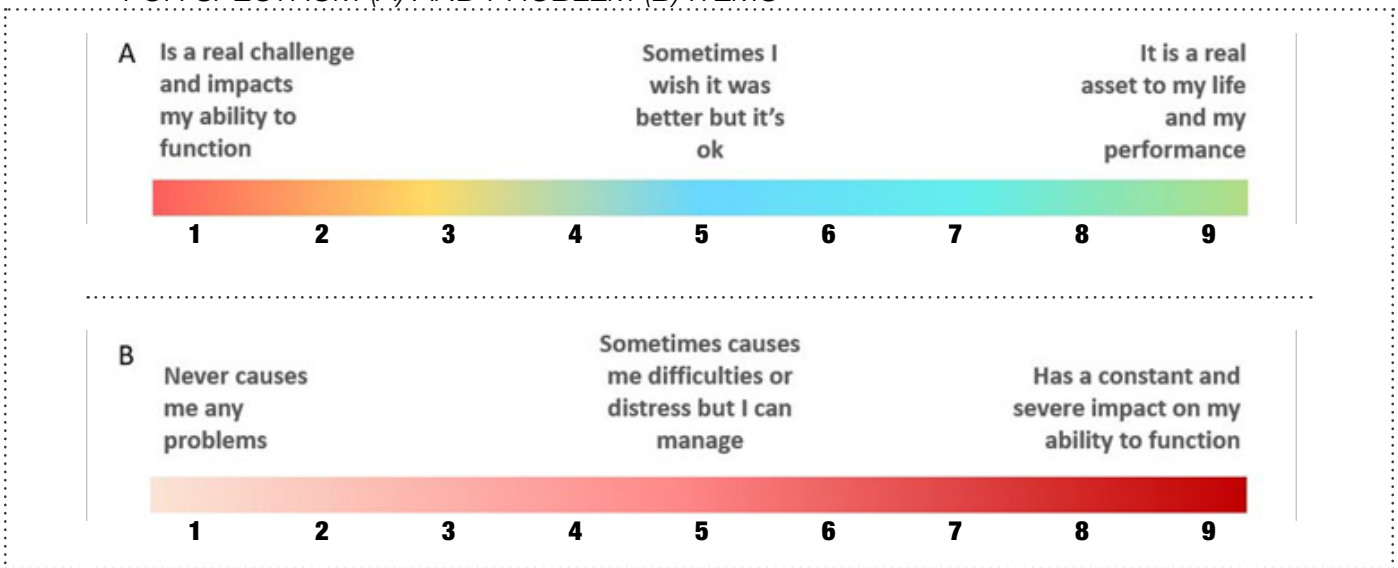


Among these 47 items there are two categories, those aspects of mental function that exist on a spectrum from negative to positive function (spectrum items, for example, Self-worth & confidence and Memory), and those that are only negative problems (problem items, for example Suicidal thoughts & intentions). Two different life impact rating formats are therefore used within the assessment (Figure 4), both on a 9-point scale. For the spectrum items (27 questions) 1 refers to "Is a real challenge and impacts my ability to function effectively", 9 refers to "It is a real asset to my life and my performance", and 5 refers to "Sometimes I wish it was better, but it's ok". In contrast, in the 9-point scale of problem items (20 questions) 1 refers to "Never causes me any problems", 9 refers to "Has a constant and severe impact on my ability to function effectively", and 5 refers to "Sometimes causes me difficulties or distress but I can manage".

Following the creation of this assessment, we then sought to develop an aggregate metric based on ratings for these 47 items. Most assessments that use a number-based rating scale simply compute an aggregate score as either the sum or average of raw scores across all questions, (e.g., [14,19]. However, this can result in individuals who are "middle of the road" on all rated items having the same score as individuals who have several very severe problems in some areas and no problems in others. In addition, an individual with a small number of severe problems will have a lower score than an individual with a larger number of severe problems although both may be equally incapacitated functionally. As an analogy within the domain of physical health, if rating scores on all physical problems were averaged, an individual whose only symptom was severe breathing difficulties would score more favorably than an individual with multiple moderate symptoms of fever, cough, cold and body ache. However, the individual with breathing difficulties may well be worse off functionally and have a higher probability of dying than the individual with multiple moderate symptoms. The same principle applies to mental health where functional capability is not necessarily about the number of symptoms, but about which symptoms they are, and their severity of consequence. The relevance and success of any scoring metric is therefore dependent on its ability to distinguish the more serious challenges from the less serious challenges.

Here we describe our metric of mental wellbeing called the Mental Health Quotient or MHQ that is constructed to overcome the various limitations of existing metrics described above. The objective of this paper is to describe this aggregate metric of mental wellbeing based on a comprehensive assessment of mental functioning that relates to both feeling as well as a person's ability to function in life, adequately distinguishes at risk individuals, and relates linearly to functional productivity. Fundamentally, we sought to develop a metric that positions individuals on a continuum from distressed to thriving and that was as close to linear as possible across the scale of function such that moving the same number of points in any direction from any place on the scale had a similar functional implication.

Figure 4 - *ILLUSTRATION OF THE 1-9 LIFE IMPACT RATING SCALE FOR SPECTRUM (A) AND PROBLEM (B) ITEMS*



2. METHODS

2.1. Demonstration of the MHQ Scoring Algorithm

2.1.1 DATA SAMPLE

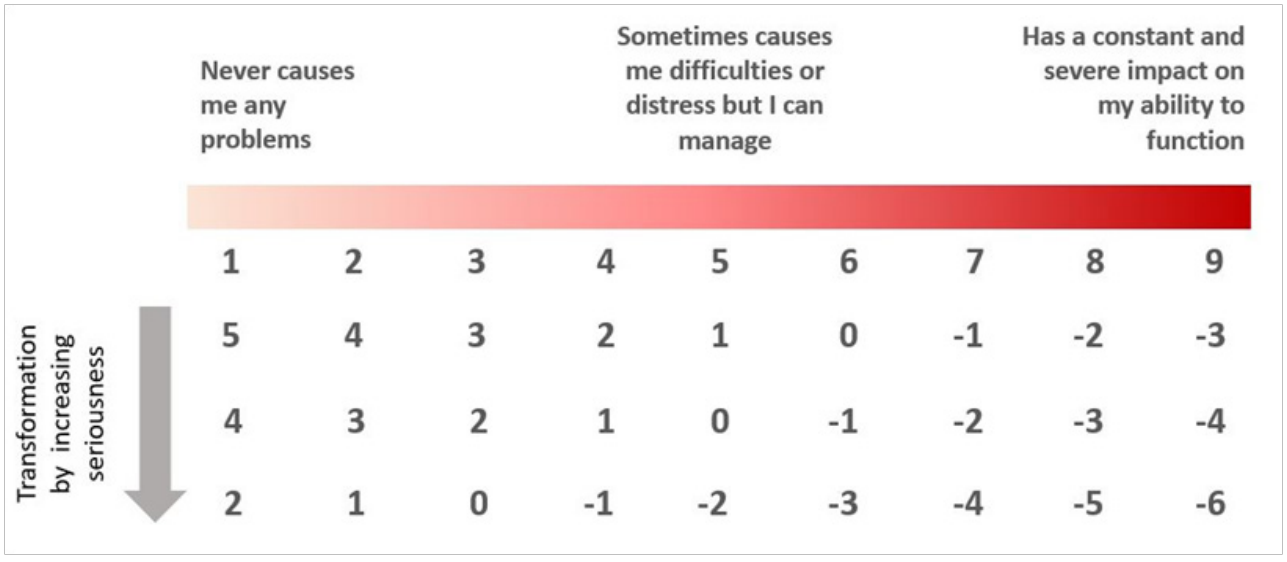
The data were taken from the Global Mind open-access database (20). The sample included responses from 100,000 adults from 140+ countries collected between January 2023 and March 2023. Participants were recruited via outreach campaigns on Facebook and using Google Ads by targeting a broad cross-section of adults aged 18-85 years that spanned wide geographic and socioeconomic demographics. All respondents completed the anonymous online MHQ assessment, providing ratings for the 47 elements as well as answering questions on demographics and life experience factors (18). The assessment was freely available on the web for anyone to complete, and individuals took it for the purpose of obtaining their personalized mental health and wellbeing report on completion. The provision of a personal report aimed to ensure greater interest of the respondent in answering questions thoughtfully and accurately. MHQ scores were then calculated based on responses to the 47 items.

2.1.2 COMPUTATION OF THE MHQ METRIC

The MHQ scoring algorithm is not computed as a simple average or sum of raw scores, but instead transformed in 3 steps, which includes (i) a threshold-based rescaling of the 9-point scale to a positive-negative scale, (ii) the application of a differential nonlinear weighting to negative scores to better distinguish at-risk populations, and (iii) a normalization of the scale into a window of -100 to +200. Here we describe the 3 steps and the rationale behind each.

Step 1: *Categorizing symptoms by severity and negative-positive thresholding:* First, the 47 items of the MHQ were categorized into three levels of functional severity based on their potential consequences to the individual or those around them. For example, *Suicidal thoughts or intentions* was categorized as having higher functional severity, while *Restlessness & hyperactivity* was considered as having lower functional severity. This means that on a 1-9 rating scale, *Suicidal thoughts or intentions* has a lower threshold (e.g. >4) at which rating values are considered 'negative' compared to *Restlessness & hyperactivity* (e.g. >6). Due to directional differences in the spectrum and problem rating scales, this transformation is applied to problem items as "N – (rating response)", while for spectrum items it is applied as "(rating response) – N", where N = the level of functional severity. The specific values of N across the 47 items form part of a proprietary MHQ algorithm. Overall, this results in a shift of the life impact scale such that the 1-9 rating scale becomes a negative-positive scale where 0 is the threshold between negative and positive. Broadly this threshold distinguishes those who are distressed or struggling at a level that requires intervention to help them function better (below 0) versus those who are simply managing normal ups and downs of life (above 0). An illustrative example for three tiers of problems is shown in Figure 5.

Figure 5 - *SHIFTED SCALE FOR THREE TIERS OF INCREASING FUNCTIONAL SEVERITY OF PROBLEMS*



Step 2: *Nonlinear amplification of the scale:* Following this positive-negative thresholding, a nonlinear transformation is then applied to the scale to amplify the more negative scores and create greater distinction of at-risk groups by stretching out the negative side of the scale compared to the positive side (Figure 6).

This transformation varies across the 47 items, and again, was determined based on an evaluation of their functional severity, so that negative scores for items with higher functional severity become more negative than negative scores for items with lower functional severity. For example, a negative score of −7 for Suicidal thoughts or intentions is amplified more negatively than a −7 for Restlessness and hyperactivity and therefore contributes more negatively to the MHQ score. Similarly, a rescaled negative score of −2 for Energy levels is amplified more negatively than a −2 for Creativity and problem solving and contributes more negatively to the MHQ score. Following this transformation, the scores across the 47 items are summed such that individuals with negative scores on items with high functional severity are differentiated from those with negative scores for items with lower functional severity, even if their ratings for other items indicated they are doing ok for those items. As a consequence, the transformed distribution shifts from a normal distribution that you would observe if all ratings were simply summed together (Figure 7A), into a long-tailed distribution (Figure 7B).

Figure 6:
NONLINEAR TRANSFORMATION OF THE SCALE THAT MAKES NEGATIVE VALUES MORE NEGATIVE

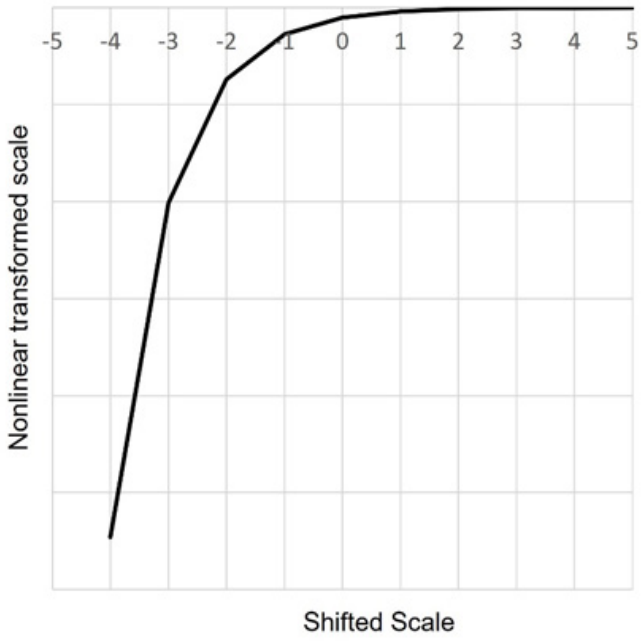
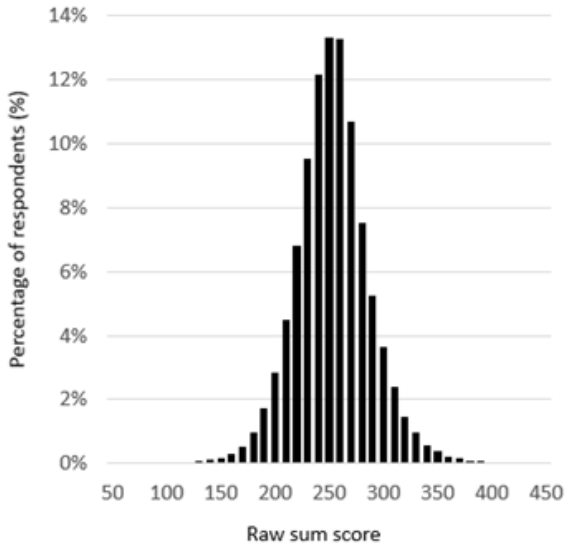
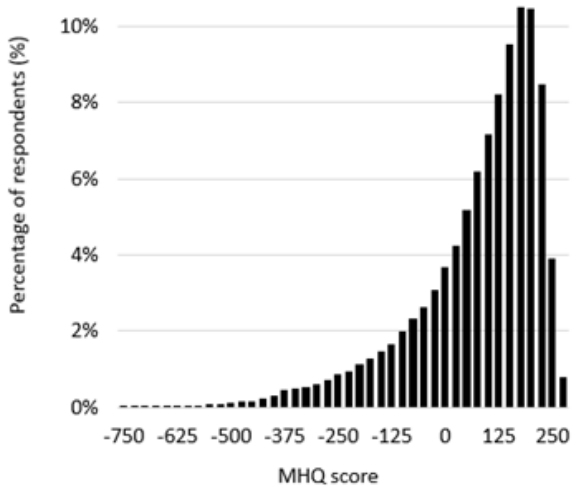


Figure 7 - *COMPARISON OF SUM SCORES AND TRANSFORMED SUM SCORES*

A | Distribution of sum scores for 47 elements across the whole population.

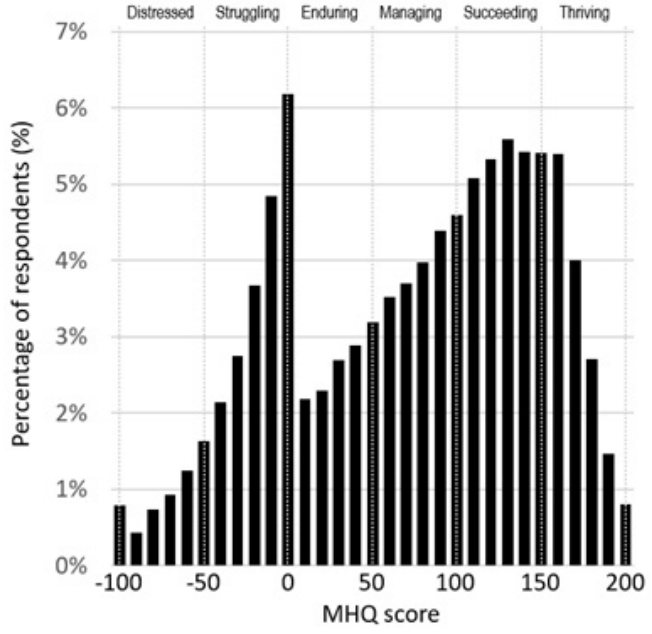


B | Distribution of transformed sum scores for 47 elements across the whole population after thresholding and nonlinearly transforming the scale.



Step 3: *Normalizing the MHQ scale:* Following the creation of this long-tailed distribution to separate out individuals who are severely struggling with their mental wellbeing, we then normalize the scale to bring it back into a functional range. This serves two purposes, first to re-linearize the life impact and second to present scores that minimized any psychological distress that could be induced by receiving a highly negative score. This is accomplished by differently normalizing the negative and positive sides of the distribution so that the positive side of the scale ranges from 0 to 200 and the negative side ranges from -1 to -100. Essentially, this compresses the long negative tail of the distribution to the left of the 0 value in the transformed distribution (Figure 7B) so that 99% of individuals fall between -1 and -100 (Figure 8) with individuals within the remaining 1% placed within the -100 group, resulting in a slightly higher prevalence in this group. The 99% value is used to normalize the negative scale (rather than 100%) because including this final 1%, which extends out far in the long-tailed distribution, compresses the majority of the data into too few score bins and reduces the resolution and linear range of the scores. For the purpose of interpretation, the scale is banded from distressed to thriving as shown in Figure 8.

Figure 8:
MHQ SCORES OBTAINED AFTER NORMALIZING THE NEGATIVE AND POSITIVE SIDES OF THE TRANSFORMED SUM SCORES, TOGETHER WITH THE MHQ SCORE BANDING FROM DISTRESSED TO THRIVING



2.2. Validation of functional productivity

2.2.1 DATA SAMPLE

Given that the primary criterion was to develop a score that was as linear as possible across the scale with respect to function, we examined functional productivity by asking 7,626 respondents two additional questions:

(1) How many days during the past month were you able to work and carry out your normal activities, but could not get as much done because of problems with your physical or mental health? (Days unproductive)

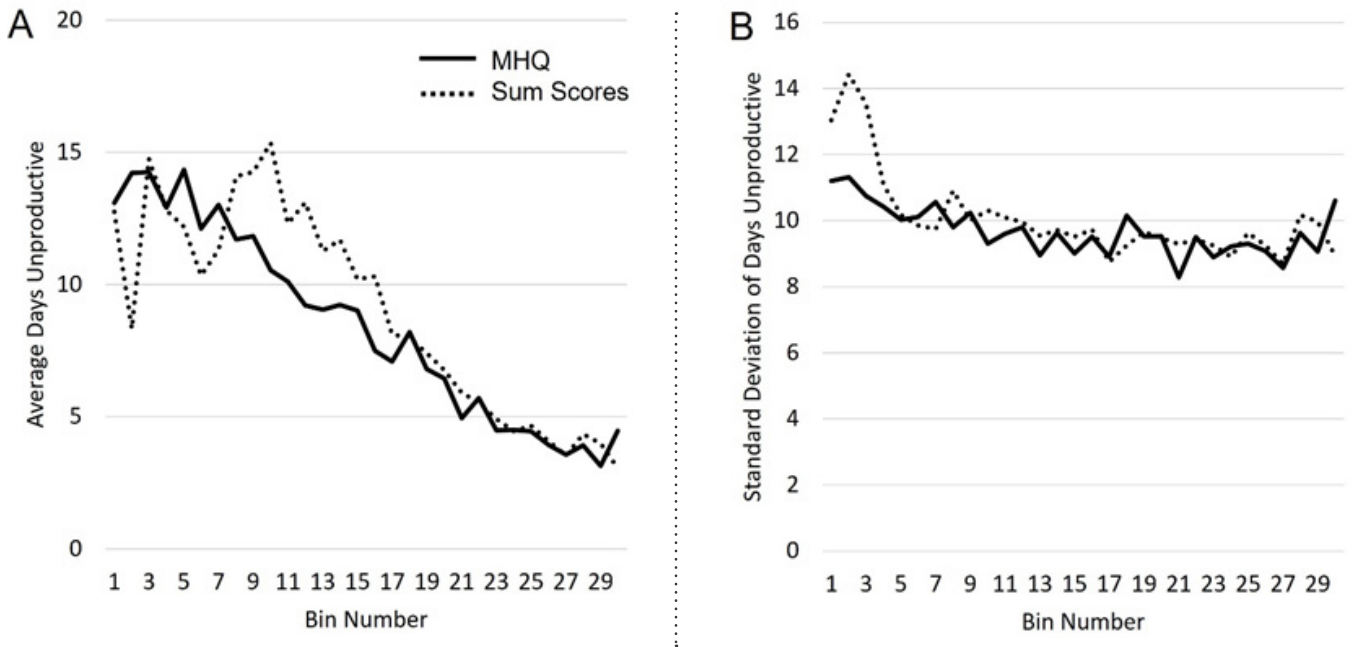
(2) How many days during the past month were you totally unable to work or carry out your normal activities because of problems with your physical or mental health (Days absent).

This data was obtained in September 2021. Respondents who completed the assessment in under 7 minutes (the minimum time needed to read all questions), took more than 60 minutes to complete the assessment, found that assessment difficult to understand (answered "No" to the question: Did you find this assessment easy to understand?), or had responses with a standard deviation of less than 0.2 (representing people who answered with the same value across all 47 rating items) were excluded. This resulted in 7,377 responses (55% female, aged 18+) being available the final analysis. We then analyzed the relationship between days unproductive and days absent and MHQ scores as well as the simple sum of ratings across all elements (sum scores) for an equal number of bins for both score types.

2.2.2 COMPUTING THE RELATIONSHIP BETWEEN THE MHQ SCORE AND FUNCTIONAL PRODUCTIVITY

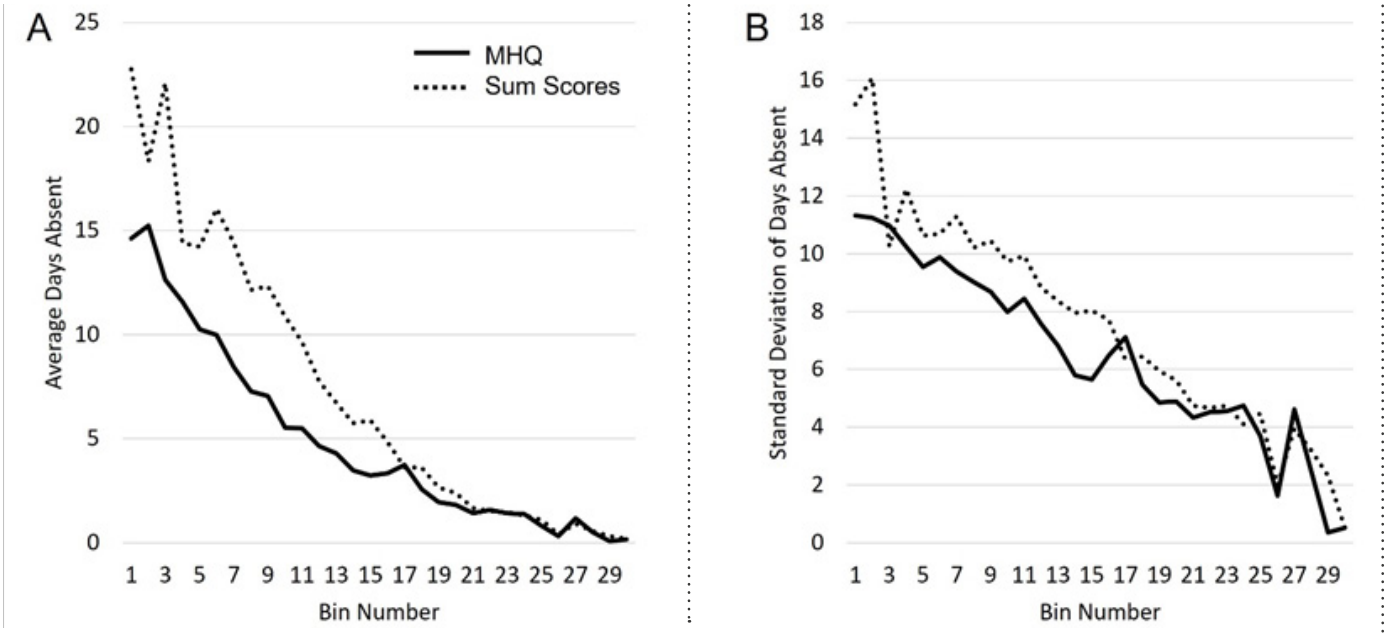
Analysis of the relationship between MHQ score and functional productivity showed that days unproductive changed linearly across the range of MHQ scores. Across the entire scale the linear fit had an R2 of 0.95 ($p<0.001$). In contrast to the linear relationship with MHQ scores, days unproductive changed linearly only in the upper third of sum scores and was essentially flat across the lower third. Across the full range of sum scores, the linear fit had an R2 of only 0.77. Thus, while a change of 10 MHQ points in any direction and at any point on the scale resulted in a similar functional change in terms of days unproductive, the bottom half of sum scores did not have any change in days unproductive (Figure 9A; see Supplementary Table 1 for a statistical comparison between each bin). We note, however, that the standard deviation within each bin was similar between MHQ scores and sum scores except at the very lowest 5 bins, where sum scores had much higher standard deviation, indicating that there was much greater functional variability at this end of the scale for sum scores (Figure 9B).

Figure 9 - *AVERAGE NUMBER OF DAYS UNPRODUCTIVE* **(A)** *AND CORRESPONDING STANDARD DEVIATION VALUES* **(B)** *FOR EACH SCORE BIN FOR MHQ SCORES (SOLID LINE) AND SUM SCORES (DOTTED LINE)*



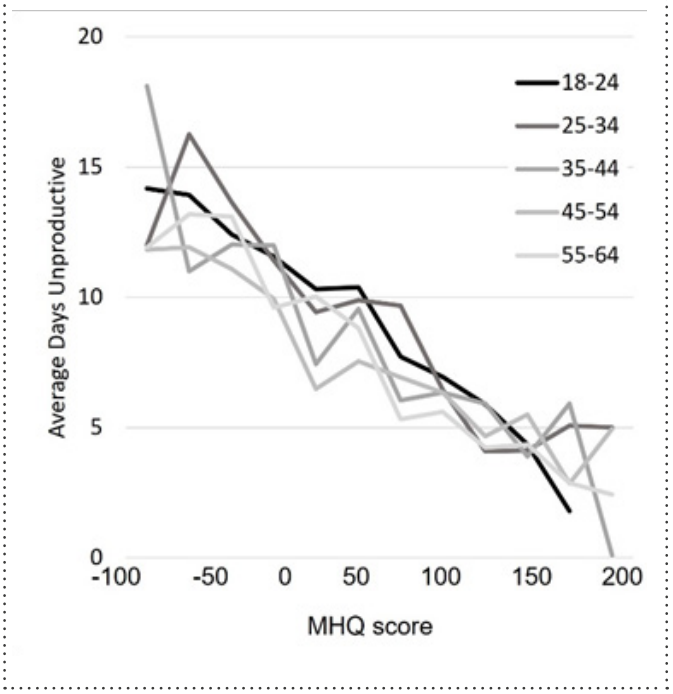
In contrast, days absent from work, which included absences due to both physical and mental health challenges, changed more exponentially than linearly for both sum scores as well as MHQ scores (Figure 10A; see Supplementary Table 2 for a statistical comparison between each bin). However, the standard deviation of days absent within each bin, particularly in the bottom half of scores, was ~2 days lower for MHQ scores than for sum scores showing that MHQ scores within each bin range were more functionally similar compared to sum scores (Figure 10B). Thus, altogether, MHQ scores provide a measure of overall mental wellbeing that is a more reliable functional metric than sum scores.

Figure 10 - *AVERAGE NUMBER OF DAYS ABSENT* **(A)** *AND CORRESPONDING STANDARD DEVIATION VALUES* **(B)** *FOR EACH SCORE BIN FOR MHQ SCORES (SOLID LINE) AND SUM SCORES (DOTTED LINE).*



We next looked at the relationship to productivity by age groups. One can imagine that different generations, or people at different stages in life, may evaluate the life impact of various mental functions differently based on their cultural perceptions and life experience. In addition, the specific symptoms that are dominant may vary by age. To determine if this relationship between productivity and mental wellbeing held constant by age, we plotted MHQ against days unproductive for each decadal grouping (Figure 11). For MHQ scores, the relationship with days unproductive was the same for each age group suggesting that, at an aggregate population level, the functional consequences of MHQ scores were comparable for all age groups. In contrast, sum scores were not only nonlinear but also highly variable across age groups in the upper third of the scale (Supplementary Figure 1; note that the scale is reversed with higher scores which indicate higher problems on the left). Thus, altogether, shifts along the MHQ scale provide a more linear and consistent readout of productive function than sum scores for all adult age groups.

Figure 11:
RELATIONSHIP BETWEEN DAYS UNPRODUCTIVE AND MHQ SCORES ACROSS DIFFERENT AGE GROUPS



3. RESULTS

3.1. Application of the MHQ assessment and metric

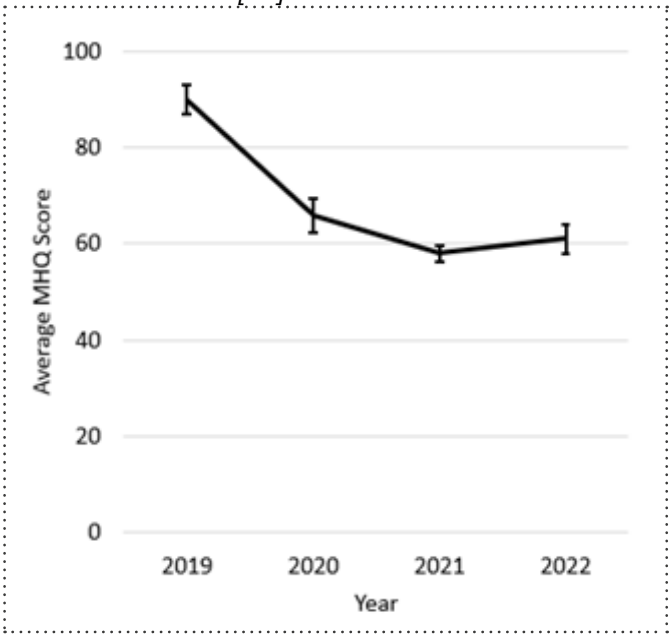
The MHQ assessment and metric are used within the Global Mind Project, an initiative that aims to track and understand our evolving mental wellbeing on a global scale and currently spans 140+ countries and 11 languages [21]. As of May 2023, the MHQ assessment had been taken by over 1 million people. In addition to providing a readout of the mental wellbeing of citizens across the world, the project also collects data on a broad range of demographic, lifestyle, and life experience factors, that are used to provide a deeper understanding of the factors that promote or compromise people's mental wellbeing. The inclusion of these factors also enable data samples to be described across multiple dimensions and constructed into representative samples that can be matched or weighted across geographies using commonly used descriptors such as age, gender or educational attainment. Beyond this, they also allow for the construction of more nuanced data samples that reflect the diversity of human populations across a wide variety of lifestyle and life experience factors (e.g. frequency of exercise, diet, childhood adversity & trauma).

Here we describe some of the results from this Project that demonstrate the potential of this metric for tracking the evolution of mental wellbeing and identifying key drivers of population shifts.

3.1.1 TRACKING MENTAL WELLBEING OVER TIME

The mental wellbeing of individuals and populations is not fixed, but instead varies over time in response to social and global factors. The Covid-19 pandemic was an example of a global event that had a substantial impact on population mental health as demonstrated by numerous studies documenting a rise in the prevalence of depression and anxiety [22–24]. However, while traditional diagnostic and assessment approaches track the rise in specific disorders or specific symptom combinations in line with clinical frameworks such as the DSM-5, these do not adequately capture people's symptomatic experience which is highly heterogeneous, overlaps across multiple disorders, and changes over time [25–28]. Moreover, relying on assessment tools which only focus on clinical symptoms, precludes a holistic understanding of population mental wellbeing where individuals fall along a spectrum from distressed to thriving. While the Global Mind Project now collects data from over 140 countries, data collection began in 2019 from 8 English speaking countries. Computing the MHQ metric over time from these countries (see Supplementary Table 3 for N values and statistical comparison between consecutive years) provides a unique holistic perspective on how population mental wellbeing has dynamically changed. To date, the results show that in the aggregate, MHQ scores dropped from an average of 90±3.2 (SEM across countries) pre-pandemic (in 2019) to an average of 58±1.7 in 2021, increasing only marginally to 61±3.0 in 2022 (Figure 12) [29]. In productivity terms by using the equation of best fit, this translates to an increase in unproductive days of ~2 per month from 2019 to 2022. Altogether, this gives an example of how the MHQ metric can be used to provide a perspective on how the mind of the world is changing and by inference, its productive capacity.

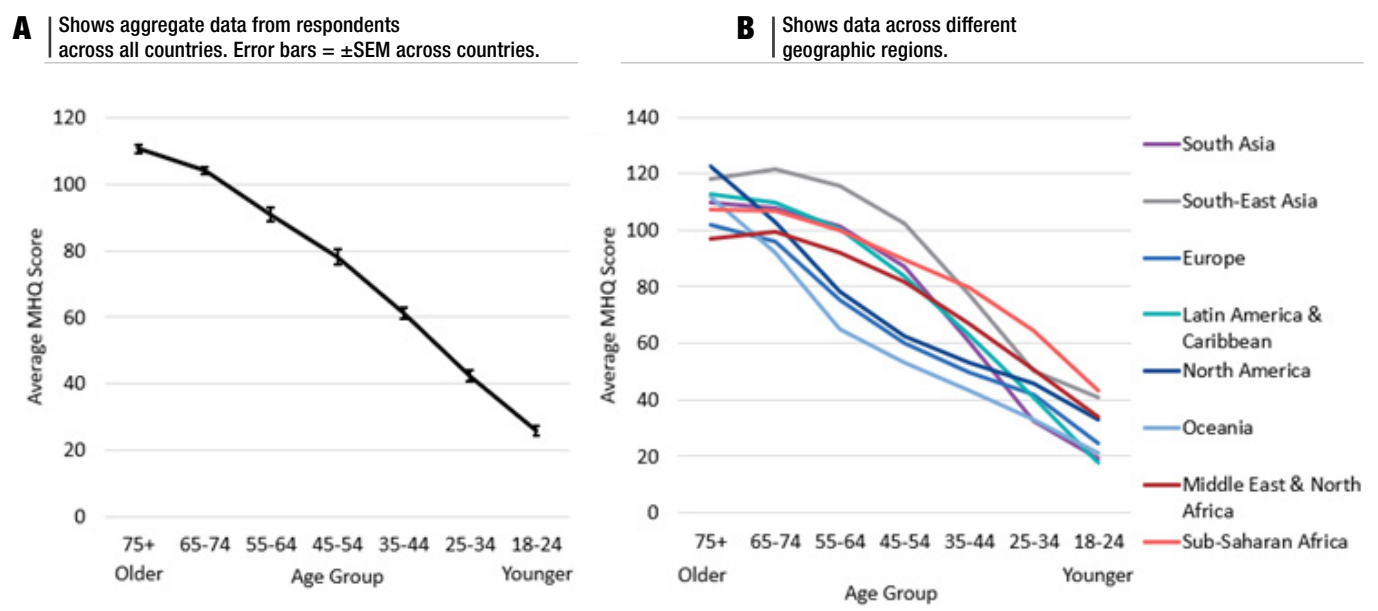
Figure 12:
TRACKING CHANGES IN AVERAGE MHQ SCORE FROM 2019 TO 2022 ACROSS 8 ENGLISH-SPEAKING COUNTRIES. ERROR BARS = ±SEM ACROSS COUNTRIES. ADAPTED FROM [29]



3.1.2 THE DECLINE IN MENTAL WELLBEING ACROSS GENERATIONS

Another major trend that has been documented, particularly in western countries, where more epidemiological studies have been carried out, is an increase in rates of depression, anxiety and other mental health disorders in younger adults and youth [30–32]. However, this data has typically been fragmented, due to methodological differences, and a focus on specific disorders or age groups. It is therefore not known how mental wellbeing has changed in the aggregate, nor how this shift looks across all age groups. If one were to aggregate all the epidemiological studies of various disorders it would still be substantially difficult, if not impossible, to determine the aggregate change in mental wellbeing given the substantial comorbidities and overlap of symptoms across disorders. While Global Mind data is not collected from youth under 18, we are able to examine the trend by age throughout adulthood using the MHQ metric. We show here that average MHQ scores decreased with each successively younger age group across the global sample (Figure 13A; all comparisons between age groups: $p<0.001$; t-test) and with a similar pattern observed across multiple regions of the globe (Figure 13B). See [29] for further details.

Figure 13 - *RELATIONSHIP BETWEEN MENTAL WELLBEING (AVERAGE MHQ SCORE) AND AGE. ADAPTED FROM [29]*



3.1.3 SOCIAL TRENDS AND THEIR RELATIONSHIP TO MENTAL WELLBEING

As a demonstration of the ability to use the MHQ assessment and metric to identify and quantify the relationship between different social trends and mental wellbeing, we provide the example of family relationships. Here we asked those who completed the MHQ assessment how close they were to their adult families (Figure 14A). Across the globe, the percentage who reported being close to many members of their family decreased with each younger generation (Figure 14B; N values and statistical comparisons shown in Supplementary Table 4). On average only 22% of young adults aged 18-24 were close to their families compared to 44% of the oldest generation aged 75+ ($p<0.001$), a two-fold difference. Conversely, 10% in the 18-24 age group did not get along with any of their family and preferred not to see them compared to only 3% of the oldest generation [$p<0.001$; (29)]. Thus, the trend of generational decline in family relationships tracks the change in mental wellbeing described above.

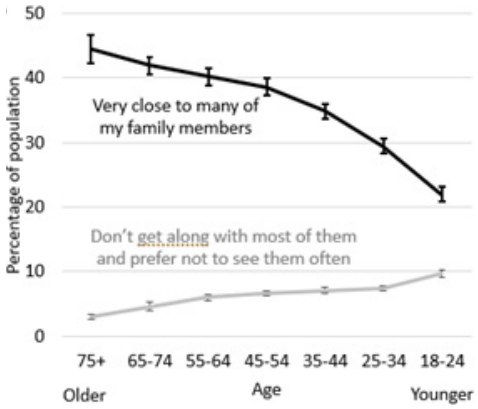
Figure 14 - *ADAPTED FROM [29]*

A | Question about family relationships within the MHQ.

How would you describe your relationships with your adult family?*

- A I don't have any family
- B I don't get along with most of them and prefer not to see them often
- C I get along OK with them but we are not close
- D I am very close to some of them but not all
- E I am very close to many of my family members
- F Prefer not to say

B | Percentage of responses (Error bars = ±SEM across countries) to the family relationship question across different age groups.

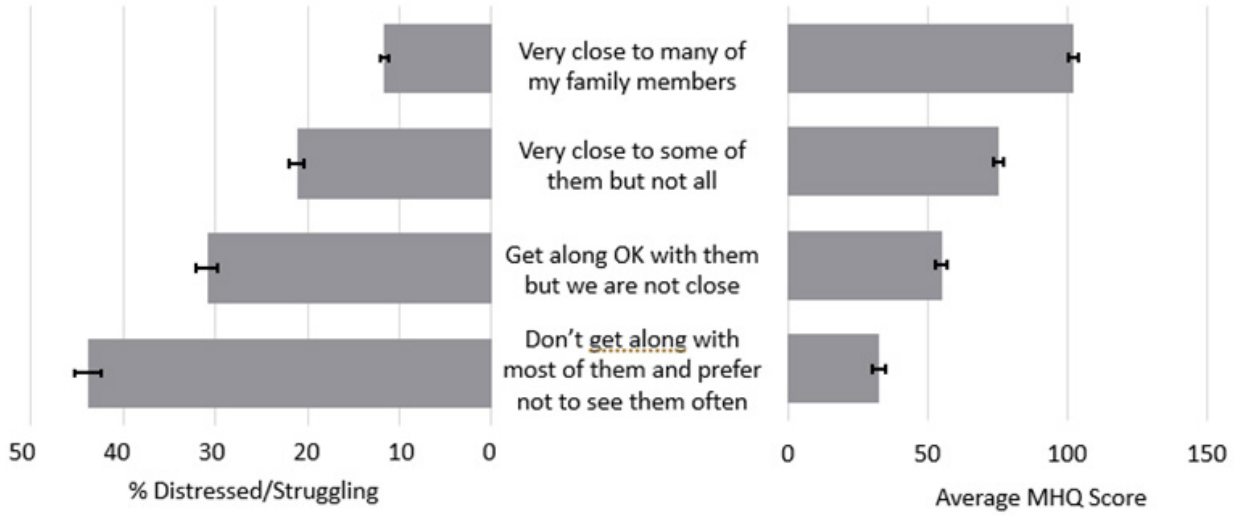


We next examined mental wellbeing across all adults for each answer group. MHQ scores were highest for those who were close to many of their family members with an average of 102±1.8 (SEM across countries), placed in the range we call 'Succeeding', and declining steadily to 33±2.5 for those who did not get along with any of their family, in the range we call "Enduring" ($p<0.001$; Figure 15; see [29] for more details). Among those close to their families, 12% still struggled with their mental health (i.e. had MHQ scores <0). However, this was almost four times lower than the 44% of those who did not get along with their families ($p<0.001$). This 70 MHQ point difference and four-fold differential in mental health struggles was consistent across all age groups. This is a profound difference in risk, twice that of the mental health risks associated with other factors such as lack of exercise, lack of education or unemployment [33,34].

While this does not prove definitively that deteriorating family relationships are the cause of poor mental wellbeing or vice versa, it demonstrates the ability to use the MHQ metric to identify relationships that can then be studied in more detail with respect to the specific aspects of mental health that are impacted, and then validated in follow-up studies.

Figure 15 - *RELATIONSHIP BETWEEN FAMILY RELATIONSHIPS AND MENTAL WELLBEING ACROSS ALL RESPONDENTS IN THE DATA SAMPLE. ADAPTED FROM [29]*

Left panel shows the % distressed or struggling (error bars show SEM across countries). | Right panel shows the average MHQ scores (error bars show SEM across countries).



3.2 Strengths of the MHQ metric

THE MHQ METRIC HAS A NUMBER OF STRENGTHS THAT ARE IMPORTANT TO HIGHLIGHT.

1) It is based on an assessment derived from a comprehensive set of mental feelings and functions that spans 10 major mental health disorders as well as other neuroscientific and dementia frameworks. It therefore encompasses a holistic view of mental wellbeing that is more direct and comprehensive than other metrics that are typically inferred from social factors or based on unidimensional measures of life satisfaction.

2) The assessment, although comprehensive, has been compiled in the most parsimonious manner possible, thereby enabling large-scale data acquisition by ensuring that assessment duration is not a barrier for completion. The MHQ metric therefore has the scope for application across large global populations.

3) It is constructed using a life impact scale and nonlinear algorithm that results in a linear relationship to productive function across the entire scale. This allows a functional interpretation of the score with practical life implications.

4) It provides a perspective of the full spectrum of mental wellbeing from distressed to thriving such that it is possible to track subclinical changes in mental wellbeing that may not be immediately obvious in epidemiological studies that are based on traditional diagnostic criteria.

Overall, the MHQ metric is a first of its kind aggregate measure of mental wellbeing that is a direct and comprehensive measure of mind and its wellbeing rather than being inferred from life satisfaction or social factors. Based on an assessment that is amenable to large scale data acquisition, it is therefore a unique tool for measuring and tracking the mental wellbeing of populations in various contexts. For instance, it can be used by schools, companies, and governments to provide a readout of how students, employees and citizens are faring, understand key drivers that can guide the development of targeted interventions, policies or strategies, and measure the impact of their implementation.

3.3 Limitations of the MHQ metric

While the MHQ metric is based on the most comprehensive assessment of wellbeing currently available, one limitation is that no assessment that is amenable to ease of completion can capture all the nuances of mental health and wellbeing. One area where psychologists tend to focus is personality, where certain characteristics or traits can drive differential functional outcomes. The MHQ assessment touches on mental functions that could be considered personality traits (e.g. optimism) but does not comprehensively capture personality traits. While we concede this as a limitation, we also point out that there is a trade-off between the universe of functions and traits and the ability to construct a practical assessment that is easy to complete.

A second limitation is that the metric arises from an assessment that utilizes self-report. Since feeling is by its nature subjective, and there are no objective metrics (e.g., biomarkers) of feelings, any metric of mental wellbeing must rely on the self-report of these feelings. This is true of any assessment in the domains of psychiatry and psychology. It is therefore particularly important to benchmark self-reported ratings to more objectively measured functional outcomes. While being absent from work is a fairly objective metric, being unproductive is more subjective. In future, we plan to benchmark the MHQ metric against other objective measures of capability and productivity, such as testing of cognitive capability and tracking of time-use.

Finally, as environmental circumstances and culture changes, it will be important to reassess the set of functions and problems captured and their relationship to functional productivity. New mental functions and challenges may emerge in new environmental contexts as our expectations, the type of work we are required to do, and the tools that we have available to us change. That said, such changes are unlikely to take place on the time scale of a few years but rather on a time scale of a decade or more.

4. IN CONCLUSION

We present the MHQ as a metric of mental wellbeing that encompasses both feeling and function and aligns with the WHO definition of mental wellbeing (5) and is amenable to large scale population monitoring. Going beyond feelings of life satisfaction and happiness, it comprehensively captures 47 elements of mental feeling and function to position individuals on a scale from distressed to thriving. Crucially, movement on the scale from any point or in any direction relates to an equivalent shift in productive ability.

5. CONFLICT OF INTEREST

One author (TT) received a grant award from the National Institute of Mental Health (NIMH) to develop a commercial version of the MHQ tool referenced herein for clinical use. All other authors do not have any competing interest.

6. AUTHOR CONTRIBUTIONS

Both authors jointly contributed to analysis and writing of the manuscript. Both authors approved the final version.

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10 DATA AVAILABILITY STATEMENT

The full dataset from the Global Mind Project is freely available for not-for profit purposes from the Sapien Labs Researcher Hub. Access can be requested here: https://sapienlabs.org/mental-health-million-project/researcher-hub/.