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**Validation of the Collaborative Outcomes study on Health and Functioning during Infection Times (COH-FIT) questionnaire for adults**

Marco Solmi1,2,3,4,5,\* Trevor Thompson6,\* Andrés Estradé4,7, Agorastos Agorastos8, Joaquim Radua4,9,10, Samuele Cortese11, Elena Dragioti12,13, Friedrich Leisch14, Davy Vancampfort15, Lau Caspar Thygesen16, Harald Aschauer17, Monika Schloegelhofer17, Elena Akimova17, Andres Schneeberger18, Christian G. Huber19, Gregor Hasler20, Philippe Conus21, Kim Q. Do Cuénod21, Roland von Känel22, Gonzalo Arrondo11,23, Paolo Fusar-Poli4,24,25, Philip Gorwood26,27, Pierre-Michel Llorca28, Marie-Odile Krebs27,29, Elisabetta Scanferla26, Taishiro Kishimoto30, Golam Rabbani31, Karolina Skonieczna-Żydecka32, Paolo Brambilla33,34, Angela Favaro35, Akihiro Takamiya30, Leonardo Zoccante36, Marco Colizzi37, Julie Bourgin38, Karol Kamiński39, Maryam Moghadasin40, Soraya Seedat41, Evan Matthews42, John Wells42, Emilia Vassilopoulou43, Ary Gadelha44, Kuan-Pin Su45,114, Jun Soo Kwon46, Minah Kim47, Tae Young Lee48, Oleg Papsuev49, Denisa Manková50, Andrea Boscutti33, Cristiano Gerunda35, Diego Saccon51, Elena Righi52, Francesco Monaco53, Giovanni Croatto54, Guido Cereda33, Jacopo Demurtas55, Natascia Brondino25, Nicola Veronese56, Paolo Enrico33, Pierluigi Politi25, Valentina Ciappolino34, Andrea Pfennig57, Andreas Bechdolf58, Andreas Meyer-Lindenberg59, Kai G. Kahl60, Katharina Domschke61, Michael Bauer57, Nikolaos Koutsouleris62, Sibylle Winter63, Stefan Borgwardt64, Istvan Bitter65, Judit Balazs66,67, Pal Czobor65, Zsolt Unoka65, Dimitris Mavridis68, Konstantinos Tsamakis69, Vasilios P. Bozikas8, Chavit Tunvirachaisakul70, Michael Maes70, Teerayuth Rungnirundorn70, Thitiporn Supasitthumrong70, Ariful Haque31, Andre R. Brunoni71, Carlos Gustavo Costardi44, Felipe Barreto Schuch72, Guilherme Polanczyk71, Jhoanne Merlyn Luiz73, Lais Fonseca44, Luana V. Aparicio71, Samira S. Valvassori73, Merete Nordentoft74, Per Vendsborg75, Sofie Have Hoffmann16, Jihed Sehli20, Norman Sartorius76, Sabina Heuss77, Daniel Guinart78,79,80, Jane Hamilton81, John Kane78,82, Jose Rubio78,82, Michael Sand83, Ai Koyanagi84, Aleix Solanes9, Alvaro Andreu-Bernabeu85, Antonia San José Cáceres85, Celso Arango85, Covadonga M. Díaz-Caneja85, Diego Hidalgo-Mazzei86, Eduard Vieta86, Javier Gonzalez-Peñas85, Lydia Fortea9, Mara Parellada85, Miquel A. Fullana9, Norma Verdolini87, Eva Fárková 50, Karolina Janků50, Mark John Millan88, Mihaela Honciuc28, Anna Moniuszko-Malinowska89, Igor Łoniewski32,90, Jerzy Samochowiec91, Łukasz Kiszkiel92, Maria Marlicz32, Paweł Sowa39, Wojciech Marlicz93,94, Georgina Spies41, Brendon Stubbs95, Joseph Firth96, Sarah Sullivan97, Asli Enez Darcin98, Hatice Aksu99, Nesrin Dilbaz100, Onur Noyan100, Momoko Kitazawa30, Shunya Kurokawa30, Yuki Tazawa30, Alejandro Anselmi6, Cecilia Cracco6, Ana Inés Machado6, Natalia Estrade6, Diego De Leo101, Jackie Curtis102, Michael Berk103, Philip Ward104, Scott Teasdale103, Simon Rosenbaum104, Wolfgang Marx103, Adrian Vasile Horodnic105, Liviu Oprea105, Ovidiu Alexinschi106, Petru Ifteni107, Serban Turliuc105, Tudor Ciuhodaru108, Alexandra Bolos105, Valentin Matei109, Dorien H. Nieman110, Iris Sommer111,112, Jim van Os113, Therese van Amelsvoort114, Ching-Fang Sun115,116, Ta-wei Guu117, Can Jiao118, Jieting Zhang118, Jialin Fan118, Liye Zou118, Xin Yu119, Xinli Chi118, Philippe de Timary120, Ruud van Winkel121, Bernardo Ng122, Edilberto Pena122, Ramon Arellano122, Raquel Roman122, Thelma Sanchez122, Larisa Movina49, Pedro Morgado123,124, Sofia Brissos125, Oleg Aizberg126, Anna Mosina127, Damir Krinitski128, James Mugisha129, Dena Sadeghi-Bahmani130,131, Farshad Sheybani132, Masoud Sadeghi133, Samira Hadi134, Serge Brand131,135,136,137,138, Antonia Errazuriz139, Nicolas Crossley139, Dragana Ignjatovic Ristic140, Carlos López-Jaramillo141, Dimitris Efthymiou43, Praveenlal Kuttichira142, Roy Abraham Kallivayalil143, Afzal Javed144, Muhammad Iqbal Afridi145,146,147, Bawo James148, Omonefe Joy Seb-Akahomen149, Jess Fiedorowicz1, Andre F. Carvalho103, Jeff Daskalakis150, Lakshmi N. Yatham151, Lin Yang152, Tarek Okasha153, Aïcha Dahdouh154, Björn Gerdle12, Jari Tiihonen10, Jae Il Shin155, Jinhee Lee156, Ahmed Mhalla157, Lotfi Gaha157, Takoua Brahim158, Kuanysh Altynbekov159, Nikolay Negay159, Saltanat Nurmagambetova159, Yasser Abu Jamei160, Mark Weiser161, Christoph U. Correll63,78,79**§**

\* Joint first authors

**§ Corresponding author:** Christoph U. Correll, MD, Department of Child and Adolescent Psychiatry, Psychosomatic Medicine and Psychotherapy, Charité University Medical Center, Campus Virchow, Augustenburger Platz 1, D-13353, Berlin, Germany. Tel.: +49 30 450 566202 , Fax: +49 30 450 566921 , E-mail: [christoph.correll@charite.de](mailto:christoph.correll@charite.de)

Affiliations

1University of Ottawa, Department of Psychiatry, Ontario, Canada

2The Ottawa Hospital, Department of Mental Health, Ontario, Canada

3University of Ottawa, Ottawa Hospital Research Institute (OHRI) Clinical Epidemiology Program, Ottawa Ontario

4Early Psychosis: Interventions and Clinical-detection (EPIC) Lab, Department of Psychosis Studies, Institute of Psychiatry, Psychology& Neuroscience, King’s College London, London, United Kingdom

5Centre for Innovation in Mental Health-Developmental Lab, School of Psychology, University of Southampton, and NHS Trust, Southampton, United Kingdom

6University of Greenwich, School of Human Sciences, London, United Kingdom

7Universidad Católica, Department of Psychology, Montevideo, Uruguay

8Aristotle University of Thessaloniki, II. Dept. of Psychiatry, Division of Neurosciences, Medical School, Faculty of Health Sciences, Greece

9Institut d’Investigacions Biomèdiques August Pi i Sunyer (IDIBAPS), Imaging of Mood- and Anxiety-Related Disorders (IMARD), CIBERSAM, Barcelona, Spain

10Karolinska Institutet, Centre for Psychiatric Research and Education, Department of Clinical Neuroscience, Stockholm, Sweden

11University of Southampton, Centre for Innovation in Mental Health, Southampton, United Kingdom

12Linköping University, Pain and Rehabilitation Centre and Department of Health, Medicine and Caring Sciences, Linköping, Sweden

13University of Ioannina, Research Laboratory Psychology of Patients, Families & Health Professionals, Department of Nursing, School of Health Sciences, Ioannina, Greece

14University of Natural Resources and Life Sciences, Wien, Austria

15Katholieke Universiteit Leuven (KU Leuven), Department of Rehabilitation Sciences, Leuven, Belgium

16National Institute of Public Health, University of Southern Denmark, Denmark

17BioPsyC - Biopsychosocial Corporation, Non-profit association for Research Funding Ltd., Vienna, Austria

18University of California San Diego, California, United States

19University of Basel, Universitäre Psychiatrische Kliniken Basel (UPK), Basel, Switzerland

20University of Fribourg, Fribourg Network of Mental Health (RFSM), Fribourg, Switzerland

21University of Lausanne, Department of Psychiatry, Lausanne, Switzerland

22University Hospital Zurich, Department of Consultation-Liaison Psychiatry and Psychosomatic Medicine, Switzerland

23University of Navarra, Mind-Brain Group, Institute for Culture and Society (ICS), Pamplona, Spain

24OASIS service, South London and Maudsley NHS Foundation Trust, London, United Kingdom

25University of Pavia, Department of Brain and Behavioral Sciences, Pavia, Italy

26Université de Paris, CMME, GHU Paris Psychiatrie et Neurosciences, Paris, France

27Institute de Psychiatrie et Neuroscience de Paris, INSERM U1266, F-75014, Paris, France

28Université Clermont Auvergne, CHU Clermont-Ferrand, Service de Psychiatrie B, Clermont-Ferrand, France

29Université de Paris, PEPIT, GHU Paris Psychiatrie et Neuroscience, Paris, France

30Keio University School of Medicine, Department of Neuropsychiatry, Tokyo, Japan

31The National Foundation of Mental Health of Bangladesh, Bangladesh

32Pomeranian Medical University in Szczecin, Department of Biochemical Sciences, Szczecin, Poland

33University of Milan, Department of Pathophysiology and Transplantation, Milan, Italy

34 Fondazione IRCCS Ca’ Granda Ospedale Maggiore Policlinico, Department of Neurosciences and Mental Health, Milan, Italy

35University of Padua, Neurosciences Department, Padua, Italy

36Integrated University Hospital of Verona, Child and Adolescent Neuropsychiatry Unit, Maternal-Child Integrated Care Department, Verona, Italy

37University of Udine, Psychiatry Department, Italy

38Service de Psychiatrie de l’enfant et de l’adolescent, GHNE, 91440 Bures Sur Yvette, France

39Medical University of Białystok, Department of Population Medicine and Lifestyle Diseases Prevention, Bialystok, Poland

40Kharazmi University, Department of Clinical Psychology, Faculty of Psychology and Education, Tehran, Iran

41Stellenbosch University, Department of Psychiatry, Faculty of Medicine and Health Sciences, South Africa

42Waterford Institute of Technology, School of Health Sciences, Waterford, Ireland

43University of Nicosia, Department of Life and Health Sciences, Nicosia, Cyprus

44Universidade Federal de São Paulo, Department of Psychiatry, São Paulo, Brazil

45An-Nan Hospital, China Medical University, Department of Psychiatry, Tainan, Taiwan

46Seoul National University College of Medicine, Department of Psychiatry, Seoul, Republic of Korea

47Seoul National University Hospital, Department of Neuropsychiatry, Seoul, Republic of Korea

48Pusan National University Yangsan Hospital, Department of Psychiatry, Yangsan, Republic of Korea

49Moscow Research Institute of Psychiatry, Moscow, Russia

50National Institute of Mental Health, Klecany, Czech Republic

51AULSS4 Veneto Orientale, Addictions Department, Italy

52University of Modena and Reggio Emilia, Department of Biomedical, Metabolic and Neural Sciences, Modena, Italy

53ASL Salerno, Department of Mental Health, Salerno, Italy

54University of Padova, Padova, Italy

55University of Modena and Reggio Emilia, Clinical and Experimental Medicine PhD Program, Modena, Italy

56University of Palermo, Department of Internal Medicine, Geriatrics Section, Palermo, Italy

57 Technische Universität Dresden, University Hospital Carl Gustav Carus, Department of Psychiatry and Psychotherapy, Dresden, Germany

58University of Cologne, Cologne, Germany

59Heidelberg University, Central Institute of Mental Health, Medical Faculty Mannheim, Germany

60Hannover Medical School, Department of Psychiatry, Social Psychiatry and Psychotherapy, Germany

61University of Freiburg, Department of Psychiatry and Psychotherapy, Medical Center – University of Freiburg, Faculty of Medicine, Freiburg, Germany

62Ludwig-Maximilians-University of Munich, Munich, Germany

63Charité Universitätsmedizin Berlin, Department of Child and Adolescent Psychiatry, Berlin, Germany

64University of Lübeck, Lübeck, Germany

65Semmelweis University, Department of Psychiatry and Psychotherapy, Budapest, Hungary

66Eotvos Lorand University, Institute of Psychology, Budapest, Hungary

67Bjørknes University College, Oslo, Norway

68University of Ioannina, Department of Primary Education, Ioannina, Greece

69King’s College London, Institute of Psychiatry, Psychology and Neuroscience, London, United Kingdom

70Chulalongkorn University, Department of Psychiatry, Thailand

71Faculdade de Medicina da Universidade de São Paulo, Departments of Internal Medicine and Psychiatry, São Paulo, Brazil

72Universidade Federal de Santa Maria, Department of Sports Methods and Techniques, Santa Maria, RS, Brazil

73Universidade do Extremo Sul Catarinense, Translational Psychiatry Laboratory, Graduate Program in Health Sciences, Criciúma, SC, Brazil

74University of Copenhagen, Copenhagen, Denmark

75Psykiatrifonden, Copenhagen, Denmark

76Association for the Improvement of Mental Health Programmes (AMH), Switzerland

77FHNW University of Applied Sciences and Arts Northwestern Switzerland, Switzerland

78The Zucker Hillside Hospital, Northwell Health, New York, USA

79Donald and Barbara Zucker School of Medicine at Hofstra/Northwell, New York, USA

80Universitat Autònoma de Barcelona, Centro de Investigación Biomédica en Red de Salud Mental (CIBERSAM), Institut de Neuropsiquiatria i Addiccions (INAD), Hospital del Mar, Institut Hospital del Mar d’Investigacions Mèdiques (IMIM), Departament de Psiquiatria, Barcelona, Spain

81University of Texas Health Science Center Houston, McGovern Medical School, Louis A. Faillace, MD, Department of Psychiatry and Behavioral Sciences, USA

82Feinstein Institutes for Medical Research, New York, USA

83Boehringer-Ingelheim, USA

84Parc Sanitari Sant Joan de Deu, Research and Development Unit, CIBERSAM, ICREA, Barcelona, Spain

85Hospital General Universitario Gregorio Marañón, Department of Child and Adolescent Psychiatry, Institute of Psychiatry and Mental Health (IPS MARAÑÓN), IiSGM, CIBERSAM, Madrid, Spain

86University of Barcelona, Hospital Clínic, IDIBAPS, CIBERSAM, Barcelona, Spain

87University of Barcelona, Hospital Clínic, Bipolar and Depressive Disorders Unit, Institute of Neuroscience, IDIBAPS, CIBERSAM, Barcelona, Spain

88Glasgow University, Institute of Neuroscience and Psychology, College of Medicine, Vet and Life Science, Glasgow, United Kingdom

89Medical University of Białystok, Department of Infectious Diseases and Neuroinfections, Poland

90Sanprobi Sp. z o.o. Sp. k, Poland

91Pomeranian Medical University in Szczecin, Department of Psychiatry, Szczecin, Poland

92University of Białystok, Institute of Sociology, Society and Cognition Unit, Białystok, Poland

93Pomeranian Medical University in Szczecin, Department of Gastroenterology, Szczecin, Poland

94The Centre for Digestive Diseases Endoklinika, Szczecin, Poland

95King’s College London, London, United Kingdom

96University of Manchester, Division of Psychology and Mental Health, Manchester, United Kingdom

97University of Bristol, Bristol, United Kingdom

98Istanbul Basaksehir Cam ve Sakura City Hospital, Department of Psychiatry, Istanbul, Turkey

99Adnan Menderes University Department of Child and Adolescent Psychiatry, Aydın, Turkey

100Uskudar University, Department of Psychiatry and Psychology, Istanbul, Turkey

101Griffith University, South East Queensland, Australia

102Mindgardens Neuroscience Network, Sydney, Australia

103Deakin University School of Medicine, Victoria, Australia

104UNSW Sydney, School of Psychiatry, Sydney, Australia

105University of Medicine and Pharmacy Grigore T. Popa, Faculty of Medicine, Iasi, Romania

106Institute of Psychiatry "Socola", Iasi, Romania

107Transilvania University of Brasov, Faculty of Medicine, Brasov, Romania

108Emergency Hospital "Nicolae Oblu", Iasi, Romania

109Psychiatry Department, University of Medicine and Pharmacy "Carol Davila" Bucharest, "Prof. Dr. Alexandru Obregia" Psychiatric Hospital, Bucharest, Romania

110Academisch Medisch Centrum Universiteit van Amsterdam, Amsterdam, The Netherlands

111 University Medical Center Groningen, University of Groningen, Cognitive Neurosciences, Department of Biomedical Sciences of Cells & Systems, Groningen, The Netherlands

112University Medical Center Groningen, University of Groningen, Department of Psychiatry, Groningen, The Netherlands

113Utrecht University Medical Centre, Department of Psychiatry, Utrecht, The Netherlands

114Maastricht University, Department of Psychiatry and Neuropsychology, Maastricht, The Netherlands

115China Medical University Hospital, Mind-Body Interface Research Center, Taichung, Taiwan

116Department of Psychiatry and Behavioral Medicine, Carilion Clinic Virginia Tech Carilion School of Medicine, Roanoke, VA, USA

117China Medical University Beigang Hospital, Division of Psychiatry, Department of Internal Medicine, Taiwan

118Shenzhen University, School of Psychology, Shenzhen, China

119Peking University Institute of Mental Health, Department of Public Mental Health, Pekin, China

120 UCLouvain, Institute of Neuroscience and Cliniques Universitaires Saint-Luc, Department of Adult Psychiatry, Brussels, Belgium

121Katholieke Universiteit Leuven (KU Leuven), Department of Neurosciences, Leuven, Belgium

122Asociación Psiquiátrica Mexicana, Mexico

123University of Minho, Life and Health Sciences Research Institute (ICVS), School of Medicine, Braga, Portugal

124ICVS/3B’s - PT Government Associate Laboratory, Braga/Guimarães, Portugal

125Lisbon’s Psychiatric Hospital Centre, Department of Psychiatry, Portugal

126Belarusian Medical Academy of Postgraduate Education, Belarus

127Clienia AG, Wetzikon Psychiatric Centre, Switzerland

128Integrated Psychiatry Winterthur (IPW), Switzerland

129Kyambogo University, Department of Sociology and Social Administration, Kampala, Uganda

130Stanford University, Department of Psychology, California, USA

131Universitäre Psychiatrische Kliniken Basel (UPK), Center of Affective, Stress and Sleep Disorders (ZASS), Basel, Switzerland

132Department of Clinical Psychology, Mashhad University of Medical Sciences

133Kermanshah University of Medical Sciences, Medical Biology Research Center, Kermanshah, Iran

134Kharazmi University, Tehran, Iran

135University of Basel, Department of Sport, Exercise, and Health, Division of Sport Science and Psychosocial Health, Basel, Switzerland

136Kermanshah University of Medical Sciences, Substance Abuse Prevention Research Center, Kermanshah, Iran

137Kermanshah University of Medical Sciences, Sleep Disorders Research Center, Kermanshah, Iran

138Tehran University of Medical Sciences, School of Medicine, Tehran, Iran

139Pontificia Universidad Católica de Chile, Department of Psychiatry, School of Medicine, Santiago, Chile

140University of Kragujevac, Department of Psychiatry, Faculty of Medical Sciences, Kragujevac, Serbia

141University of Antioquia, Department of Psychiatry, Medellín, Colombia

142Jubilee Mission Medical College & Research Institute, Thrissur, India

143Pushpagiri Institute of Medical Sciences, Deptartment of Psychiatry, Thiruvalla, Kerala, India

144Chairman, Pakistan Psychiatric Research Centre-Fountain House, Lahore, Pakistan

145Dean, Faculty of Psychiatry, College of Physicians and Surgeons, Pakistan

146Dean, Jinnah Postgraduate Medical Centre, Karachi, Pakistan

147Dean, Faculty of Medicine, Jinnah Sindh Medical University, Karachi, Pakistan

148Federal Neuropsychiatric Hospital, Department of Clinical Services, Benin-City, Nigeria

149Irrua Specialist Teaching Hospital, Department of Psychiatry, Edo State, Nigeria

150University of Toronto, Toronto, Canada

151University of British Columbia, Vancouver, Canada

152University of Calgary, Alberta Health Services, Calgary, Canada

153Okasha Institute of Psychiatry, Faculty of Medicine, Ain Shams University, Cairo, Egyp

154Oran 1 University, Department of Psychiatry-Addictology, Oran, Algeria

155Yonsei University College of Medicine, Department of Pediatrics, Seoul, South Korea

156Yonsei University Wonju College of Medicine, Department of Psychiatry, Wonju, South Korea

157University of Monastir, Research Unit "Vulnerability to Mental Disorders" LR05ES10, Monastir, Tunisia

158University of Monastir, University Hospital of Monastir, Department of Psychiatry, Monastir, Tunisia

159Republican Scientific and Practical Center of Mental Health, Kazakhstan

160Gaza Community Mental Health Programme, Palestine

161Sheba Medical Center, Israel

**Email addresses**

| **Country or region** | **Name, Surname** | **Contact** |
| --- | --- | --- |
| Italy | Marco Solmi | marco.solmi83@gmail.com |
| Uruguay | Andrés Estradé | andres.estrade\_vaz@kcl.ac.uk |
| United Kingdom | Trevor Thompson | T.Thompson@greenwich.ac.uk |
| Greece | Agorastos Agorastos | aagorast@auth.gr |
| Spain | Joaquim Radua | radua@clinic.cat |
| United Kingdom | Samuele Cortese | samuele.cortese@soton.ac.uk |
| Greece/ Sweden | Elena Dragioti | elena.dragioti@liu.se |
| Austria | Friedrich Leisch | Friedrich.Leisch@boku.ac.at |
| Belgium /Uganda | Davy Vancampfort | davy.vancampfort@kuleuven.be |
| Denmark | Lau Caspar Thygesen | lct@sdu.dk |
| Austria | Harald Aschauer | harald.aschauer@biopsyc.at |
| Austria | Monika Schloegelhofer | monika.schloegelhofer@biopsyc.at |
| Austria | Elena Akimova | elena.akimova@biopsyc.at |
| Switzerland | Andres Schneeberger | aschneeberger@health.ucsd.edu |
| Switzerland | Christian G. Huber | christian.huber@unibas.ch |
| Switzerland | Gregor Hasler | gregor.hasler@unifr.ch |
| Switzerland | Philippe Conus | philippe.conus@chuv.ch |
| Switzerland | Kim Q. Do Cuénod | Kim.Do@chuv.ch |
| Switzerland | Roland von Känel | roland.vonkaenel@usz.ch |
| Spain | Gonzalo Arrondo | garrondo@unav.es |
| Italy/ United Kingdom | Paolo Fusar-Poli | paolo.fusar-poli@unipv.it |
| France | Philip Gorwood | p.gorwood@ghu-paris.fr |
| France | Pierre-Michel Llorca | pmllorca@chu-clermontferrand.fr |
| France | Marie-Odile Krebs | MO.KREBS@ghu-paris.fr |
| ​France | ​Elisabetta Scanferla | ​e.scanferla@ghu-paris.fr |
| Japan | Taishiro Kishimoto | tkishimoto@keio.jp |
| Bangladesh | Golam Rabbani | rabbanigolam33@gmail.com |
| Poland | Karolina Skonieczna-Żydecka | karzyd@pum.edu.pl |
| Italy | Paolo Brambilla | paolo.brambilla1@unimi.it |
| Italy | Angela Favaro | angela.favaro@unipd.it |
| Japan | Akihiro Takamiya | akihiro.takamiya@keio.jp |
| Italy | Leonardo Zoccante | leonardo.zoccante@aovr.veneto.it |
| Italy | Marco Colizzi | marco.colizzi@uniud.it |
| France | Julie Bourgin | j.bourgin@gh-nord-essonne.fr |
| Poland | Karol Kamiński | fizklin@gmail.com |
| Iran | Maryam Moghadasin | mmoghadasin@yahoo.com |
| South Africa | Soraya Seedat | sseedat@sun.ac.za |
| Ireland | Evan Matthews | ematthews@wit.ie |
| ​Ireland | ​John Wells | ​jswells@wit.ie |
| Cyprus | Emilia Vassilopoulou | vassilopoulouemilia@gmail.com |
| Brazil | Ary Gadelha | aryararipe@gmail.com |
| Taiwan | Kuan-Pin Su | cobolsu@gmail.com |
| South Korea | Jun Soo Kwon | kwonjs@snu.ac.kr |
| South Korea | Minah Kim | verte82@snu.ac.kr |
| South Korea | Tae Young Lee | leetaey@gmail.com |
| Russia | Oleg Papsuev | oleg.papsouev@gmail.com |
| Czech Republic | Denisa Manková | denisa.mankova@nudz.cz |
| Italy | Andrea Boscutti | a.boscutti@gmail.com |
| Italy | Cristiano Gerunda | cristiano.gerunda@unipd.it |
| ​Italy | ​Diego Saccon | ​diego.saccon@aulss4.veneto.it |
| Italy | Elena Righi | elena.righi@unimore.it |
| Italy | Francesco Monaco | fmonaco1980@gmail.com |
| Italy | Giovanni Croatto | giovannicroatto8@gmail.com |
| Italy | Guido Cereda | guido.cereda@unimi.it |
| Italy | Jacopo Demurtas | eritrox7@gmail.com |
| Italy | Natascia Brondino | natascia.brondino@unipv.it |
| Italy | Nicola Veronese | nicola.veronese@unipa.it |
| Italy | Paolo Enrico | paolo.enrico@unimi.it |
| Italy | Pierluigi Politi | pierluigi.politi@unipv.it |
| Italy | Valentina Ciappolino | valentina.ciappolino@policlinico.mi.it |
| Germany | Andrea Pfennig | Andrea.Pfennig@uniklinikum-dresden.de |
| Germany | Andreas Bechdolf | andreas.bechdolf@uk-koeln.de |
| Germany | Andreas Meyer-Lindenberg | Andreas.Meyer-Lindenberg@zi-mannheim.de |
| Germany | Kai G. Kahl | kahl.kai@mh-hannover.de |
| Germany | Katharina Domschke | katharina.domschke@uniklinik-freiburg.de |
| Germany | Michael Bauer | Michael.Bauer@uniklinikum-dresden.de |
| Germany | Nikolaos Koutsouleris | Nikolaos.Koutsouleris@med.uni-muenchen.de |
| Germany | Sibylle Winter | sibylle.winter@charite.de |
| Germany | Stefan Borgwardt | s.borgwardt@unibas.ch; stefan.borgwardt@uksh.de |
| Hungary | Istvan Bitter | bitter.istvan@med.semmelweis-univ.hu |
| Hungary | Judit Balazs | balazs.judit@ppk.elte.hu |
| Hungary | Pal Czobor | czobor.pal@med.semmelweis-univ.hu |
| Hungary | Zsolt Unoka | unoka.zsolt@med.semmelweis-univ.hu |
| Greece | Dimitris Mavridis | dmavridi@uoi.gr |
| Greece | Konstantinos Tsamakis | ktsamakis@gmail.com |
| Greece | Vasilios P. Bozikas | mpozikas@auth.gr |
| Thailand | Chavit Tunvirachaisakul | chavit.T@chula.ac.th |
| Thailand | Michael Maes | dr.michaelmaes@hotmail.com |
| Thailand | Teerayuth Rungnirundorn | drteerayuth@gmail.com |
| Thailand | Thitiporn Supasitthumrong | thitiporn.s@chula.ac.th |
| Bangladesh | Ariful Haque | arifulhaque.ukzn@gmail.com |
| Brazil | Andre R. Brunoni | brunoni@usp.br |
| Brazil | Carlos Gustavo Costardi | gustavocostardi@hotmail.com |
| Brazil | Felipe Barreto Schuch | felipe.schuch@ufsm.br |
| Brazil | Guilherme Polanczyk | polanczyk.guilherme@gmail.com |
| Brazil | Jhoanne Merlyn Luiz | jhoanne\_luiz@hotmail.com |
| Brazil | Lais Fonseca | laismfonseca@gmail.com |
| Brazil | Luana V. Aparicio | luanavma@hotmail.com |
| Brazil | Samira S. Valvassori | samiravalvassori@unesc.net |
| Denmark | Merete Nordentoft | mn@dadlnet.dk |
| Denmark | Per Vendsborg | pv@psykiatrifonden.dk |
| Denmark | Sofie Have Hoffmann | sohh@sdu.dk |
| Switzerland | Jihed Sehli | jihed.sehli@gmail.com |
| Switzerland | Norman Sartorius | sartorius@normansartorius.com |
| Switzerland | Sabina Heuss | sabina.heuss@fhnw.ch |
| United States | Daniel Guinart | DGuinart@northwell.edu |
| United States | Jane Hamilton | Jane.E.Hamilton@uth.tmc.edu |
| United States | John Kane | JKane2@northwell.edu |
| United States | Jose Rubio | JRubio13@northwell.edu |
| United States | Michael Sand | michael.sand@boehringer-ingelheim.com |
| Spain | Ai Koyanagi | a.koyanagi@pssjd.org |
| Spain | Aleix Solanes | al.solanes@gmail.com |
| Spain | Alvaro Andreu-Bernabeu | alvaro.andreu@salud.madrid.org |
| Spain | Antonia San José Cáceres | antonia.sanjose@iisgm.com |
| Spain | Celso Arango | carango@hggm.es |
| Spain | Covadonga M Díaz-Caneja | covadonga.martinez@iisgm.com |
| Spain | Diego Hidalgo-Mazzei | dahidalg@clinic.cat |
| Spain | Eduard Vieta | evieta@clinic.cat |
| Spain | Javier Gonzalez-Peñas | javipenhas@gmail.com |
| Spain | Lydia Fortea | lydiafor94@gmail.com |
| Spain | Mara Parellada | parelladahggm@gmail.com; parellada@hggm.es |
| Spain | Miquel A. Fullana | mafullana@clinic.cat |
| Spain | Norma Verdolini | norma.verdolini@gmail.com |
| Czech Republic | Eva Fárková | eva.farkova@nudz.cz |
| Czech Republic | Karolina Janků | karolina.janku@nudz.cz |
| France | Mark John Millan | mark.john.millan@gmail.com |
| France | Mihaela Honciuc | rmhonciuc@chu-clermontferrand.fr |
| Poland | Anna Moniuszko-Malinowska | annamoniuszko@op.pl |
| Poland | Igor Łoniewski | sanprobi@sanprobi.pl |
| Poland | Jerzy Samochowiec | samoj@pum.edu.pl |
| Poland | Lukasz Kiszkiel | lukaszkiszkiel@gmail.com |
| Poland | Maria Marlicz | mariamarlicz@gmail.com |
| Poland | Pawel Sowa | mailtosowa@gmail.com |
| Poland | Wojciech Marlicz | marlicz@hotmail.com |
| South Africa | Georgina Spies | ggiocos@sun.ac.za |
| United Kingdom | Brendon Stubbs | brendon.stubbs@kcl.ac.uk |
| United Kingdom | Joseph Firth | joseph.firth@manchester.ac.uk |
| United Kingdom | Sarah Sullivan | Sarah.Sullivan@bristol.ac.uk |
| Turkey | Aslı Enez Darcın | aslienez@gmail.com |
| Turkey | Hatice Aksu | aksubhatice@yahoo.com |
| Turkey | Nesrin Dilbaz | nesrin.dilbaz@gmail.com |
| Turkey | Onur Noyan | conurnoyan@gmail.com |
| Japan | Momoko Kitazawa | m-kitazawa@keio.jp |
| Japan | Shunya Kurokawa | shunya5@keio.jp; shunyakurokawa@gmail.com |
| Japan | Yuki Tazawa | tazawa@a5.keio.jp |
| Uruguay | Alejandro Anselmi | alejandro.anselmi@ucu.edu.uy |
| Uruguay | Cecilia Cracco | ccracco@ucu.edu.uy |
| ​Uruguay | ​Ana Inés Machado | ​amachado@ucu.edu.uy |
| ​Uruguay | ​Natalia Estrade | ​natalia.estrade@ucu.edu.uy |
| Australia | Diego De Leo | D.DeLeo@griffith.edu.au |
| Australia | Jackie Curtis | j.curtis@unsw.edu.au |
| Australia | Michael Berk | michael.berk@deakin.edu.au |
| Australia | Philip Ward | p.ward@unsw.edu.au |
| Australia | Scott Teasdale | s.teasdale@unsw.edu.au |
| Australia | Simon Rosenbaum | s.rosenbaum@unsw.edu.au |
| Australia | Wolfgang Marx | wolf.marx@deakin.edu.au |
| Romania | Adrian Vasile Horodnic | adrian-vasile-horodnic@umfiasi.ro |
| Romania | Liviu Oprea | liviu.oprea@umfiasi.ro; liviu.oprea@gmail.com |
| Romania | Ovidiu Alexinschi | alexinschi@yahoo.com |
| Romania | Petru Ifteni | petru\_ifteni@yahoo.com |
| Romania | Serban Turliuc | serban\_turliuc@yahoo.com |
| Romania | Tudor Ciuhodaru | tudorciuhodaru@yahoo.co.uk |
| Romania | Alexandra Bolos | alex\_andra\_bolos@yahoo.com |
| Romania | Valentin Matei | valipmatei@yahoo.com |
| Netherlands | Dorien H. Nieman | d.h.nieman@amc.uva.nl |
| Netherlands | Iris Sommer | i.e.c.sommer@umcg.nl |
| Netherlands | Jim van Os | j.j.vanos-2@umcutrecht.nl |
| Netherlands | Therese van Amelsvoort | t.vanamelsvoort@maastrichtuniversity.nl |
| Taiwan | Ching-Fang Sun | chingfangsun@gmail.com |
| Taiwan | Ta-wei Guu | da20vid@gmail.com |
| China | Can Jiao | jiaocan@szu.edu.cn |
| China | Jieting Zhang | jenny121@126.com |
| ​China | ​Jialin Fan | ​FanJL@szu.edu.cn |
| China | Liye Zou | liyezou123@gmail.com |
| China | Xin Yu | yuxin@bjmu.edu.cn |
| China | Xinli Chi | xinlichi@126.com |
| Belgium | Philippe de Timary | Philippe.detimary@uclouvain.be |
| Belgium | Ruud van Winkel | ruud.vanwinkel@kuleuven.be |
| Mexico | Bernardo Ng | bng@sunvalleyb.com |
| Mexico | Edilberto Pena | epena@cisne.mx |
| Mexico | Ramon Arellano | jramonarellanoc@hotmail.com |
| Mexico | Raquel Roman | raquelrr@hotmail.com |
| Mexico | Thelma Sanchez | marsan2@prodigy.net.mx |
| Russia | Larisa Movina | movina\_larisa@bk.ru |
| Portugal | Pedro Morgado | pedromorgado@med.uminho.pt |
| Portugal | Sofia Brissos | brissos.sofia@gmail.com |
| Belarus | Oleg Aizberg | oleg.aizberg@gmail.com |
| Belarus/ Russia | Anna Mosina | annamosina.md@gmail.com |
| Belarus/ Russia | Damir Krinitski | damir.krinitski@gmail.com |
| Uganda | James Mugisha | Jmmugi77@hotmail.com |
| Iran | Dena Sadeghi-Bahmani | Bahmanid@stanford.edu |
| Iran | Farshad Sheybani | sheibanifr@mums.ac.ir |
| Iran | Masoud Sadeghi | sadeghi\_mbrc@yahoo.com |
| Iran | Samira Hadi | hadi.samira@yahoo.com |
| Iran | Serge Brand | serge.brand@upk.ch |
| Chile | Antonia Errazuriz | anerrazuriz@uc.cl |
| Chile | Nicolas Crossley | ncrossley@uc.cl |
| Serbia | Dragana Ignjatovic Ristic | draganaristic4@gmail.com |
| Colombia | Carlos López-Jaramillo | carlos.lopez20@udea.edu.co; carloslopezjaramillo@gmail.com |
| Cyprus | Dimitris Efthymiou | dimitrisefthy@gmail.com |
| India | Praveenlal Kuttichira | drpraveenlalkuttichira@gmail.com |
| India | Roy Abraham Kallivayalil | roykalli@gmail.com |
| Pakistan | Afzal Javed | afzalj@gmail.com |
| Pakistan | Muhammad Iqbal Afridi | driqbalafridi@yahoo.com |
| Nigeria | Bawo James | bawojames@yahoo.com |
| Nigeria | Omonefe Joy Seb-Akahomen | sebakahomen@gmail.com |
| ​Canada | ​Jess Fiedorowicz | ​jfiedorowicz@toh.ca |
| Canada | Andre F. Carvalho | Andre.Carvalho@camh.ca |
| Canada | Jeff Daskalakis | Jeff.Daskalakis@camh.ca |
| Canada | Lakshmi N Yatham | l.yatham@ubc.ca |
| Canada | Lin Yang | lin.yang@ahs.ca |
| Egypt | Tarek Okasha | tarek.okasha@gmail.com |
| Algeria | Aïcha Dahdouh | aichadahdouh@gmail.com |
| Sweden | Björn Gerdle | bjorn.gerdle@liu.se |
| Sweden | Jari Tiihonen | jari.tiihonen@ki.se |
| South Korea | Jae Il Shin | SHINJI@yuhs.ac |
| South Korea | Jinhee Lee | jinh.lee95@yonsei.ac.kr |
| Tunisia | Ahmed Mhalla | ahmed.mhalla@yahoo.fr |
| Tunisia | Lotfi Gaha | gaha.lotfi@yahoo.fr |
| Tunisia | Takoua Brahim | takoua.brahim@yahoo.com |
| Kazakhstan | Kuanysh Altynbekov | kuanysh\_altyn@mail.ru |
| Kazakhstan | Nikolay Negay | nick\_negaj@mail.ru |
| Kazakhstan | Saltanat Nurmagambetova | saya\_n@yahoo.com |
| Palestine | Yasser Abu Jamei | yasser@gcmhp.net |
| Israel | Mark Weiser | mweiser@netvision.net.il |
| Germany/ United States | Christoph U. Correll | CCorrell@northwell.edu |

**Abstract 250/250**

**Background.** TheCollaborative Outcome study on Health and Functioning during Infection Times (COH-FIT; www.coh-fit.com) is an anonymous online survey measuring health and functioning during COVID-19 pandemic globally. The aim of this study it to test concurrently the validity of COH-FIT items and the internal validity of the co-primary outcome, a composite psychopathology “P-score”.

**Methods.** TheCOH-FIT survey has been translated into 30 languages (two blind forward-translations, consensus, one independent English back-translation, final harmonization). To measure mental health, 1-4 items (“COH-FIT items”) were extracted from validated questionnaires (e.g. Patient Health Questionnaire 9). COH-FIT items measuring anxiety, depressive, post-traumatic, obsessive-compulsive, bipolar and psychotic disorder symptoms, as well as stress, sleep, concentration, which correlated at r≥0.5 with validated questionnaires, composed the P-score. Internal validation of the P-score included Cronbach’s α/ω, exploratory factor analysis (EFA) and confirmatory factor analyses (CFA) (overall and by age group/sex). Concurrent validity of COH-FIT items was tested via correlations with validated questionnaire scores, completed by a subgroup of COH-FIT participants, overall and within languages.

**Results.** From >150,000 adult responses on 13/04/2022, 22,456 completed both COH-FIT items and validated questionnaires. Concurrent validity was demonstrated for COHFIT items of anxiety, depressive, post-traumatic, psychotic symptoms, stress, sleep and concentration items (consistently across languages). CFA revealed five first-order factors (anxiety, depression, post-traumatic, psychosis, psychophysiologic symptoms) with a single second-order factor P-score, and high internal reliabillity (ω=0.95) (consistently by age/sex).

**Conclusions.** COH-FIT is a valid instrument to measure mental health during infection times, globally. The P-score is a valid measure of multidimensional mental health.

**Introduction**

COVID-19 has infected over 530 million people and caused almost 6.3 million deaths up to June 1st, 2022, since its breakout, globally1. The indirect impact of COVID-19 on mental health of the general population has been studied by several anonymous surveys2. Recently published systematic reviews that report on literature published up to July 2020, have identified 37 mental health surveys targeting the general adult population with an average of 5,137 and a maximum of 56,679 respondents3. Up to December 2020, 35 surveys measured mental health of children and adolescents during the pandemic4, focusing on different mental health domains (on only few outcomes each though), most frequently anxiety (28%) and depression (23%), while loneliness (5%), stress (5%), fear (5%), tension (3%), anger (3%), fatigue (3%), confusion (3%), and worry (3%) were assessed much less frequently. The largest meta-analysis on the prevalence of mental health outcomes during the COVID-19 pandemic, which included 173 surveys and over 500,000 participants, showed that the highest prevalence during the COVID-19 pandemic is for posttraumatic symptoms in COVID-19-infected people (94%), but that mental health can be broadly affected by COVID-19 pandemic, including behavioral problems in those with prior mental disorders (77%), fear in healthcare workers (71%), anxiety in caregivers/relatives of people infected with COVID-19 (42%), general health/social contact/passive coping style in the general population (38%), depression in those with prior somatic disorders (37%), and fear in other-than-healthcare workers (29%)2. Females seem to be particularly hit by the pandemic overall, college students/young adults with respect to anxiety, depressive and sleep problems, and suicidal ideation, and adults with regards to post-traumatic stress disorder2.

Given the evidence of multidimensional impact of the pandemic on mental health of the general population, surveys ideally should assess a composite psychopathology domain: “p”. Many studies have shown that the many psychiatric symptoms and disorders ultimately cluster in three psychopathology dimensions (namely externalizing, internalizing, and psychotic experiences), which in turn load on a single domain of psychopathology, “p”, paralleling the “g” factor for intelligence, and mapping on a continuum from low to extreme psychopathology5,6. P is classically conceived as a latent variable, putatively associated with increased risk of developing mental disorders5,6. However, it has been proposed that P should also be considered as a mental health outcome in clinical trials, to prevent or treat mental disorders5. Accounting for this double nature of P, as a latent vulnerability factor, and as an outcome, a questionnaire measuring composite psychopathology could inform on both vulnerability for future development of mental disorders (P as a liability latent factor), and the broad mental health status (P as an outcome). To measure P, measures of individual psychopathological domains are needed. Most of the surveys conducted during COVID-19 pandemic to date have focused on one or two psychopathology domains, and have used full-length validated questionnaires, that are composed of numerous items, which has limited the number of domains that could be covered within a reasonable amount of time. For instance, among others, the Patient Health Questionnaire 9 (PHQ-9)7 was frequently used to measure depressive symptoms, the Generalized Anxiety Disorder 7 (GAD-7)8 to measure anxiety symptoms, and the post-traumatic stress disorder (PTSD) Checklist for DSM-5 (PCL-5)9 to measure post-traumatic symptoms. These questionnaires are nine, seven, and 20 items long, respectively. Hence, in the context of an online survey, using validated questionnaires to assess P would take too many items, likely decreasing completion rates of responses. An alternative approach to measure P, is to use fewer items to measure a different dimensions of mental health at the same time, minimising time demands and fatigue of the participant. Nevertheless, the use of abbreviated scales to measure mental health requires evidence that the scale validity is not adversely affected.

It is also very important to keep in mind that online surveys are not limited by borders, and that they have the potential of reaching people living in any country, and speaking any language. However, almost every online survey normally provides the option to answer in one or rarely in two languages, most frequently English, or Chinese.. This limitation is of particular concern as it can introduce selection bias since the pandemic is particularly affecting the most fragile strata of the population, including ethnic and linguistic minorities who generally have lower socio-economic status and education10,11, and who are frequently non-fluent in the official national language of the country of residence12. Hence, a multi-language survey has the potential of being more inclusive, not leaving behind any linguistic minorities, and collect evidence from as many countries globally as possible13.

However, the use of abbreviated scales to measure mental health requires evidence that scale validity is not adversely affected. Furthermore, merging item data from the same survey across multiple language translations assumes that the psychometric properties are not compromised by their presentation in a different language.

The Collaborative Outcome study on Health and Functioning during Infection Times (COH-FIT; www.coh-fit.com) is an online survey measuring the impact of COVID-19 pandemic on health and functioning of the general populations. COH-FIT is one of the largest international, multi-language (n=30), cross-sectional, anonymous online surveys for adults, adolescents (14-17 years), and children (6-13 years), measuring health and functioning during COVID-19 pandemic globally in a multi-wave design, utilizing both non-probability and representative sampling, in collaboration with over 220 researchers from all around the globe14,15. Since April 26th, 2020 up to April 13th, 2022, COH-FIT has collected over 150,000 responses from adults and over 15,000 responses from minors, in over 150 countries. The design of COH-FIT has been described and discussed in detail previously14–16. Briefly, COH-FIT assesses at the time of taking the survey and recalled for the last 2 weeks of regular life before the onset of the pandemic locally, aspects of both physical health and mental health in order to measure the impact of the pandemic, including its relationship to specific moderators and mediators of that impact. With regards to the assessment of mental health, COH-FIT, uses selected items for each psychopathology domain that were extracted from full-length validated questionnaires, which are then put together to build a composite general psychopathology P-score. The COH-FIT P-score is composed by COH-FIT items that are found to sufficiently represent that full validated scale result for anxiety, depressive, post-traumatic, obsessive-compulsive, bipolar and psychotic disorder symptoms, as well as psychophysiologic measures of stress, sleep, and concentration problems. The primary aim of this validation study was to evaluate the psychometric properties of the COH-FIT P-score by (1) examining the concurrent validity of each of the selected COH-FIT psychopathology items and domains, via examining correlations of each item with the full-length validated questionnaire for the same constructs, and (2) assessing the factor structure, internal reliability and measurement invariance across age groups and sex of the composite P-score within a structural equation modelling framework. A secondary aim was to measure validity of the translation process, to justify the pooling of COH-FIT results collected in different languages.

**Methods**

*Dataset*

The dataset examined is that from all adult respondents to the COH-FIT survey collected from April 26th, 2020 to March 13th, 2022. Data collection of the full questionnaires after completion of the COH-FIT survey was only conducted between April 26th, 2020 and xxxxxxx, i.e., until a sufficient number of participants answered these additional questions, in order to reduce the burden and time requirement for the subsequent COH-FIT participants. The validated questionnaires were deliberately placed at the end of the survey in order not to alter the survey’s structure before them, when removed. Validation scales were translated into several languages with responses distributed as follows: Hungarian (25%), Italian (20%), Greek (15%), Danish (8%), Thai (8%), English (4%), French (4%), German (4%), Spanish (4%), Japanese (2%), Dutch (1%), Polish (1%), Portugal Portuguese (1%), Turkish (1%), Romanian (<1%), Russian (1%), Traditional Chinese (<1%), Arabic (<1%), Brazilian (<1%), Czech (<1%). In addition, the entire WHO-5 questionnaire17 (co-primary outcome with the P-factor) was also administered in Bangladeshi, Simplified Chinese, Farsi, Korean, Rumantsch Grischun, Serbian, Swedish, Urdu and Xhosan.

*Data screening, languages and missing data*

Prior to the main analyses, initial data were screened through computation of minimum and maximum values for each variable to identify out-of-range values. Furthermore, a histograms were conducted to assess data distributions and identify obvious univariate outliers. In addition, for participants who completed ≥80% of the scale items, missing domain item data were imputed using multivariate chained equations. Otherwise participant data for that domain were excluded from further analysis. For COH-FIT domains with a low number of items (typically 1-2 items), domain scores were not imputed if missing.

*Representativeness of the validation sample*

To assess representativeness of the subsample that additionally completed the full-length validation questionnaires, to the wider survey sample, we compared demographic characteristics based on the following: sex, age, ethnicity, education and employment status. If any sizeable/material imbalance emerged between the validation subsample and the whole data sample, validation cases were weighted to achieve representativeness.

*COH-FIT items and c**oncurrent validity*

Concurrent validity was assessed by computing Pearson’s correlations for each of the candidate COH-FIT domain scores with an established and validated full-length measure of the same construct as follows: (1) COH-FIT anxiety domain score with GAD-78, (2) COH-FIT depression, (3) sleep, and (4) concentration domain score with PHQ-97, (5) COH-FIT post-traumatic symptoms domain score with (PCL-5)9, (6) COH-FIT obsessive-compulsive symptoms domain score with the Brief Obsessive Compulsive Scale (BOCS)18, (7) COH-FIT bipolar disorder symptoms domain score with the Altman Self-Rating Mania Scale (ARMS)19, (8) COH-FIT stress domain score with the WHO-5 wellbeing scale17, and (9) COH-FIT psychotic symptoms domain score with the Prodromal Questionnaire-16 (PQ-16)20. We selected WHO-5 as the validated questionnaire to test concurrent validity of COH-FIT stress item given the large overlap between the two concepts (i.e. stress as opposite of well-being)21, and in light of the association between WHO-5 and several stress signs and symptoms22. Only COH-FIT domains with moderate correlations >0.50 with their respective validated full-length questionnaires were considered as acceptable to be included as a component in the composite P-score. Additionally, we calculated the correlations of each individual COH-FIT item within the same domain (e.g. COH-FIT anxiety items 1 and 2) with its corresponding validation scale (e.g. GAD-7 anxiety score) to identify any poorly performing individual COH-FIT items. Any items with a correlation <.20 were not included in the scoring of that domain.

As the upper limit of a test-criterion correlation is dependent upon the reliability of the criterion, the nature of the construct and the degree of similarity of constructs across test, and criterion measures23, we only automatically excluded COH-FIT domains or items from any analysis where correlations were <0.2, but where correlations were 0.2-0.5 we considered the centrality of that item to the main analysis before deciding whether or not to exclude. The scoring of COH-FIT domains and each corresponding validation scale is provided in Supplementary Table 1.

To assess whether concurrent validity for each COH-FIT domain was still evident across different language translations of the COH-FIT items, Pearson’s correlations for every language with at least 100 valid responses were computed for all domains and plotted graphically for all COH-FIT domains (Supplementary Table 2, supplementary Figure 2). If any correlations were notably lower for a particular language within a domain, we will consider excluding data for this domain for the affected translation in further projects using global and local data.

*P-score definition and internal validation*

One of the two COH-FIT co-primary outcomes is a composite psychopathology measure (P-score) representing a multidimensional measure of symptoms of different psychopathologic domains (the other COH-FIT co-primary outcome is a re-scaled WHO-5 questionnaire), with all COH-FIT items and the WHO-5 being rated on a 0 -100 VAS scale). Only COH-FIT domains with at least moderate correlations of r ≥ 0.50 with their respective validated full-length questionnaires were considered as acceptable to be included as a component of the composite P-score.

P-score underwent an internal validation procedure. First, to identify an initial P-score factor structure, we conducted exploratory factor analysis (EFA) on a testing set after randomly dividing the data into approximately evenly split testing and validation subsamples. Factors were extracted from an initial pool of all items belonging to a COH-FIT domain using ordinary least squares EFA, with oblique rotation (oblimin) used, given our expectation of correlated factors. Horn’s parallel analysis24 was performed to determine the number of factors to retain, based on the number of ranked eigenvalues from the data that exceeded the upper 95th percentile of ranked eigenvalues generated from factor analysis of 500 simulated uncorrelated datasets.25 A rotated item loading >0.45 was considered acceptable for the COH-FIT item, indicating that an item belonged to a factor26. Second, we performed confirmatory factor analysis (CFA) on the validation set, assessing the fit of a hierarchical model using the domain-specific factors identified by the EFA as well as of an additional general psychopathologic (P) domain modelled as a second-order factor. This general second-order factor was added to evaluate the legitimacy of computing a single composite P-score in further analyses. A substantial loading of the P-domain onto all subfactors (minimum ≥0.45), and an adequate model fit with a general pattern of coherent high factor loadings (minimum ≥0.45), would support the creation of a composite P score. To demonstrate adequacy of model fit indices should be close to the following standard cut-offs of comparative fit index (CFI) >0.95, root mean square error of approximation (RMSEA) <06, standardized root mean square residual (SRMR) <0827. We did not use the chi-square test to assess significance of model fit, as even trivial deviations of a user-specified model from a fully saturated model tend to be significant when sample sizes are large (here n>20,000). Overall and individual internal domain reliabilities were estimated with coefficient ω within the CFA framework as well as the traditional coefficient α, given that α can sometimes misestimate true reliability28.

*P-score measurement invariance*

To assess equivalence of P-score measurement across males and females and age groups (18-39, 40-64, 65+ yrs.), multiple-groups CFA was performed. Measurement invariance was tested in a hierarchical manner, assessing adequacy of model fit with the following increasingly restrictive equality constraints:29,30 configural (‘weak’) measurement invariance (equal model specifications for each subgroup) and metric (‘strong’) invariance (equal factor loadings across groups). We also examined intercept invariance (equal intercepts across groups). As limitations of the chi-square test in large samples are also applicable to multi-group CFA, the CFI was used as the primary indicator of measurement invariance. Data simulations have demonstrated that an absolute change in CFI <0.002 (ΔCFI < 0.002) indicates that deviations from perfect group equivalence are practically trivial31.

All analyses were conducted in *R*32using the *MICE* 33, *ggplot2*34, *psych*35 and *lavaan*36packages.

**Results**

*Data screening*

Up to March 13th, 2022, *N* = 142,564 adults provided valid survey responses. From this sample, a smaller subsample was additionally asked to complete a set of full-length validation questionnaires. This subsample represented approximately 16% (N = 22,456) of the entire sample for the majority of the validation questionnaires, as well as approximately xx% of the sample collected until the full survey questionnaire portion of COH-FIT was discontinued to reduce participant burden. A smaller subsample was available for the PQ-16 scale, which was added at a slightly later stage of the validation process (N = 16,518). A larger sample was available for the WHO-5, as this scale was also one of the two co-primary outcomes in the main survey (and therefore a complete dataset was available) (Supplementary Table 1).

Only a very small percentage of missing item data were evident and imputed according to the procedure described above, with the vast majority of participants (ranging from 98.0% of participants for the SBQ to 99.9% for the ASRM) completing at least 80% of the total number of items for each questionnaire. Completion rates >80% of all items was similarly high for all COH-FIT domains (ranging from 97.1% for COH-FIT post-traumatic domain to 99.0% for COH-FIT anxiety domain).

Data screening found no out-of-range values. Histograms of full-length validation scales and COH-FIT domains are shown in Supplementary Figure 1 and reveal some negative skew in several validation items, as would be expected, given the non-clinical population. However, given the high sample size and that the skew was generally in the same direction for a COH-FIT validation scale domain, we did not attempt to normalise data, as the sampling distribution from which confidence intervals are derived should exhibit normality, given the tenets of the central limit theorem37.

*Sample demographics and validation sample representativeness*

Demographic characteristics of both the entire survey sample and those who completed the validation sample are provided in Table 1. To assess representativeness of the validation sample to the wider survey population, demographic characteristics for each sample were reported, suggesting that the validation subset provides a broadly representative sample of the survey population.

*Concurrent validity*

Across all COH-FIT items, only one item exhibited a correlation coefficient < 0.20, namely the “mood swings” item from the COH-FIT bipolar disorder symptom domain (*r* = 0.05 with the ASRM). This item was therefore not included in the scoring of the COH-FIT bipolar disorder symptom domain.

Figure 1 and Supplementary Table 1 show the correlation between COH-FIT domains and relative validation questionnaires. Overall, all but the COH-FIT bipolar disorder and OCD symptom domains met our threshold of *r* ≥ 0.50. As can be seen in Supplementary figure 2-3, the associations between COH-FIT ratings and external scale scores were generally highly consistent across language translations for each domain (see Supplementary Table 2 for detailed reporting of correlation coefficients).

*P-score*

As the OCD and bipolar disorder symptom COH-FIT domains did not meet our criteria for acceptable concurrent validity, these were not considered as candidate P-Score domains and therefore excluded from exploratory factor analysis (EFA). Complete data across remaining domains was available for N = 103,529, and this data set was randomly divided into a testing (N =51,629) and validation (N=51,900) subsets.

Horn’s parallel analysis24 for the remaining COH-FIT domains (anxiety, depression, PTSD, psychosis, sleep, focus and stress) was conducted, on the testing subset, with results showing that five factors were retained. Results of the EFA with five extracted factors are presented in the pattern matrix in Table 2 and show all item-factor loadings >0.45 with no complex loadings. Correlations between factors were largely moderate (mean *r* = 0.58, range = 0.27 to .77), and factor structure was largely consistent with the individual COH-FIT domains, with sleep, focus and stress loading together on a distinct “psychophysiologic” factor.

CFA on the validation set using a model, which included the 5 factors identified by EFA along with a single general factor, suggested a good model fit, with all fit indices satisfying the predefined thresholds, i.e., *CFI =* 0.98, *RMSEA =* 0.053, *SRMR =* 0.028. High indicator-factor loadings for domain-specific factors (0.66 to 0.94) were also observed, with high loadings of the P-score factor onto the five domain-specific factors (Figure 2), consistent with the existence of a general common factor and supporting the aggregation of all domain scores to a general P-score. Unstandardized loadings, standard errors and p-values for the CFA are presented in Supplementary Table 3.

Overall and individual internal scale reliabilities, estimated through ω and α coefficients, are shown in Supplementary Table 5 and suggest good reliability for the five domain-specific factors and excellent reliability for the composite P-score factor, with values above 0.70-0.80 (most commonly used as thresholds for good reliability)38. Finally, Horn’s analysis confirmed one factor retainment (Supplementary Figure 4).

*P-score measurement invariance*

Adequate model fit of the general factor model continued to be demonstrated when CFA was conducted separately in male (CFI = 0.97, RMSEA = 0.067, SRMR = 0.045) and female (CFI = 0.97, RMSEA = 0.061, SRMR = 0.044) subsamples, as well as across age groups of 18-39 years (CFI = 0.96, RMSEA = 0.067, SRMR = 0.051), 40-64 years (CFI = 0.97, RMSEA = 0.065, SRMR = 0.046) and 65+ years (CFI = 0.98, RMSEA = 0.056, SRMR = 0.040).

Factor loadings for each of these subgroups are shown in Supplementary Table 4 and appear to be generally closely equivalent across groups.

Measurement invariance tests results are shown in Supplementary table 5. All Δ*CFI*s < 0.002 for sex suggest little appreciable degradation in model fit with each increasingly restrictive constraint. For age, some degradation in model fitwas shown for factor loading invariance (*CFI* < 0.002) , and intercept invariance (*CFI* = 0.004). Nevertheless, absolute model fit indices retained acceptable fit for all invariance models for both age and sex groups.

**Discussion**

Results of this validation study show that the selected individual COH-FIT items are valid, providing reliable estimates of individual mental health domains assessed with lengthier validated scales. The selected and implemented COH-FIT items that survive the stricter validity threshold compose a P-score that is internally valid, representing one second order factor (P-score), and five first order factors (anxiety, depression, and post-traumatic, psychotic, and psychophysiologic symptoms). The translation process of the COH-FIT study proved to be solid, and responses taken in different COH-FIT study languages can be reliably put together within or across countries.

Several reasons might explain why the bipolar and obsessive-compulsive disorder symptom domains did not meet our validity threshold. Regarding obsessive-compulsive symptoms, the COVID-19 pandemic has certainly elevated the intensity and frequency of thoughts about and, even, preoccupations with contamination, infection, cleanness, and related behaviours to prevent and avoid COVID-19 infection. Such thoughts and behaviours, which are functional, adaptive, and physiologic during infection times, might have altered the psychometric properties of the full-length validated questionnaire, as well as of the corresponding abbreviated OCD COH-FIT item domain. A systematic review focusing on OCD during the COVID-19 pandemic reported a discrepancy in frequency of OCD between in-person versus online studies, with the latter reporting higher rates of OCD, possibly indicating poorer psychometric performance of established tools to screen for OCD during the COVID-19 pandemic and/or using questionnaires39. Moreover, a more recent scoping review described that obsessive-compulsive symptoms in the general population were associated with trait compulsivity and pandemic-related-stress40, which can confound symptom assessment and impact the validity of the COH-FIT domain extracted from the entire BOCS. Whether the lack of validity of OCD self-ratings affects the full validated questionnaire during time of a pandemic goes beyond the scope of this work, which mainly aims to validate COH-FIT questionnaire and not to test validity of full-length established valid questionnaires for which clinical interviews to diagnose manifest OCD would be needed.

Results are methodologically relevant. as they show that few specific items can be extracted from validated questionnaires for many relevant psychopathology domains and still sufficiently reliably measure the whole domain that the complete questionnaire is measuring. Few items provide a less granular insight of individual symptoms of depressed mood, for instance. The complete PHQ-9 is certainly superior in providing a more detailed and specific symptomatic profile compared with two COH-FIT items. However, the PHQ-9 still cannot provide measures of syndromal DSM-5 defined disorders, still being a self-report measure. Thus, unless each of the nine symptoms assessed with PHQ-9 needs to be assessed to test a specific hypothesis, fewer items might be a good trade-off between minimum required validity and broadness of an overall mental health assessment performed in future surveys.

Furthermore, results of this study clearly show that multi-language translations of online surveys, scaling them up from local to global surveys is feasible and valid. Beyond broadening the target population internationally, having a multi-language survey within a given country is also of ecological value. Selection bias invariably affects online surveys, for instance just because of their online nature (not everybody has access/is familiar with internet), and in particular if convenience sampling is adopted. Selection bias can be counterbalanced by also collecting nationally representative samples via polling agencies, but still, if the survey is available in one language only, those not fluent in the country’s main language will be left behind, will not answer, or will provide unreliable responses.

In this work we have applied the gold-standard psychometric procedure for internal and external validation of a questionnaire, namely exploratory factor analysis, confirmatory factor analysis, measured internal consistency, and tested concurrent/external validation with validated questionnaires. Similar methodologically strict approaches have been used in some but not all (online) surveys conducted during COVID-19. However, most of these scales focused on one psychopathological domain, and specifically focused on COVID-19, making them very specific for the current pandemic setting, but less exportable to future public health crises or infection times. Examples are the “fear of COVID-19 scale”41, the “COVID-19 anxiety scale”42, the “Coronavirus Anxiety Scale”43, COVID-19 Public Stigma Scale44, COVID-19 Exposure and Family Impact Scale45, COVID-19 Protective Motivation Scale46, a questionnaire on fear of COVID-19 vaccination in the general population47, to mention a few. In addition to these aforementioned and many more examples of COVID-19 focused questionnaires that underwent psychometric validation, one stems out as broader and measuring multiple mental health domains, namely the COVID-19 Pandemic Mental Health Questionnaire (CoPaQ)48. CoPaQ measured COVID-19-specific stressor impact, mental health impact, positive coping, institutional and political trust, and conspiracy beliefs, actually going beyond mental health. Important differences exist between CoPaQ and COH-FIT. First, within the mental health domain, CoPaQ considered PTSD symptoms, sleep disturbance (part of the broader COH-FIT P-score), and also substance abuse. COH-FIT deliberately avoided to consider measures of externalizing behaviour in the P-score, a-priori assuming that to properly assess such a domain in-person assessment and collateral information are crucial. Results of the methodologically sound CoPaQ validation analyses show that substance abuse poorly correlated with mental health validated questionnaires authors used (correlation coefficients all below 0.3), confirming that including externalizing symptoms proxy measures in online surveys is problematic and probably not valid. These results are not surprising, given the evidence of low reliability of questionnaires for the measurement of externalizing behaviors49. Second, authors did not extract CoPaQ items from validated questionnaires, but created COVID-19-specific questions. Notwithstanding the high specificity and value of CoPaQ during COVID-19, such a methodological approach resulted in overall low correlation of CoPaQ mental health domains with validated questionnaires (all correlation coefficient below 0.5), limiting the applicability of CoPaQ outside of COVID-19 pandemic. This study has several limitations. Among the frequent biases of online surveys3, and subjective reported experiences50, we have specifically accounted for selection bias (by including representative samples, and by comparing characteristics of validated questionnaires completers versus non completers showing no material demographic differences), short data collection duration (by continuous data collection-currently over two years of data collection), small sample size, internal and concurrent validity of selected items and questionnaires (across languages). Another limitation is that, for the P-score we did consider internalizing symptoms and thought disorder, but did not consider externalizing symptoms. As stated above, this decision was deliberate (see design paperS), and accounts for poor validity of measures of externalizing behaviors in the context of surveys49. Finally, COH-FIT has additional limitations, that are inherent in its cross-sectional design, that will be fully discussed in main reports from COH-FIT global and local studies.

The P-score we have validated in this work, parallels the P-factor construct, yet with some differences. First of all, the P-factor encompasses externalizing symptoms, P-score does not. As mentioned above this decision was deliberate. Beyond limited external validity of surveys to measure externalizing behaviours, the current pandemic introduce a global quasi-experimental scenario, with large drop in several externalizing behaviours, including crime51,52, and heterogeneous changes of substance use, and related intoxications varying across settings with different lockdown policies. For instance, in the US, where milder lockdown restrictions were implemented, intoxication and overdose emergency presentations increased53, while in other settings with stricter lockdown policies substance us did not increase, or decreased54,55. Hence, while COH-FIT did collect data on substance use and/or domestic violence, we opted not to consider those outcomes as part of the P-score, and so we did not validate related COH-FIT items. Secondly, COH-FIT models the P-score as an outcome, with a specific quantifiable score, psychometric properties, conceiving it as a measure of mental health, rather than a vulnerability factor implying additional risk of mental disorders5. We acknowledge that, to test the P-score as a transdiagnostic vulnerability factor for different mental disorders, future studies will be needed, which should account for structured a-priori transdiagnosticyt assessment frameworks56, and appropriate prognostic or prediction study designs, namely cohort studies measuring P-score at baseline and following up participants over time, measuring prognostic accuracy, discrimination performance, in development, internal, and external validation samples57,58.

In conclusion, COH-FIT is a valid tool to measure clinically relevant domains of mental health during infections times, which is available in 30 languages and provides a measure of overall mental health via a composite P-score. These results are relevant for the use of the P-score in forthcoming analyses and publications from the COH-FIT study but also for other questionnaire studies in the future. Whether the P-score reflects current psychopathology, or also increased vulnerability for mental disorders, or both, needs to be clarified in additional longitudinal studies.

**Author disclosures**

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***Conflict of Interest Statement***

Conflict of interest statements of all authors are detailed in Supplementary table 7.

***Author Contributions Statement***

TT wrote the statistical analysis plan designed the statistical analysis plan and conducted the analysis of this work. CUC, MS, TT wrote the first draft. All authors read, contributed to and approved the final version of the manuscript. For the overall COHFIT project, MS, CUC wrote the study protocol. MS, CUC, TT, SC, FL, QR, AI, ED CUC, MS, AA, AE, DV conducted a preliminary review of the available publications and ongoing registered studies. All authors contributed to the final version of the COH-FIT survey and are involved in disseminating the COH-FIT survey link and collecting the data and designing and preparing research reports on national data. All local researchers contributed to and approved translations of the COH-FIT survey in their respective language. CUC, MS, ED, TT, FL, AK had access to the global raw data on participation results.

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**Figure 1.** Pearson’s correlation of COH-FIT domain (x-axis) and criterion (y-axis) measures for each of the COH-FIT domains.

Graphical user interface, chart, application

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**Figure 2.** Factor structure of the composite psychopathology P-Score from confirmatory factor analysis.

Diagram

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**Table 1.** Sample demographics

|  |  |  |
| --- | --- | --- |
|  | Validation sample\* (N = 22,456) | Total Survey sample (N = 142,564) |
| Gender | Female 69%  Male 30%  Other or not stated <1% | Female 67%  Male 32%  Other or not stated <1% |
| Age | 42.5 years (SD = 15.0) | 41.1 years (SD = 15.6) |
| Ethnicity | White 78%  Asian 10%  Mixed 1%  Hispanic 1%  African/African-descent <1%  Other <1%  Not stated 9% | White 66%  Asian 18%  Mixed 4%  Hispanic 3%  African/African-descent 3%  Other 1%  Not stated 5% |
| Education | None <1%  Primary school 2%  High school 25%  College/university degree 64%  PhD 8% | None <1%  Primary school 3%  High school 28%  College/university degree 59%  PhD 9% |
| Job Status | Current paid job 65%  No paid job 35% | Current paid job 62%  No paid job 38% |

\*This consisted of those completing the anxiety domain (COH-FIT anxiety and GAD-7). Similar demographic distributions were observed for other domains.

**Table 2.** Loading matrix of P-Score in exploratory factor analysis

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Anxiety | Depression | PTSD | Psychosis | Psychophysiologic |
| anxiety01 | .88 | .01 | -.01 | .00 | .05 |
| anxiety02 | .71 | .10 | .09 | .05 | -.02 |
| depression01 | -.01 | .96 | -.02 | .00 | .00 |
| depression02 | .14 | .69 | .08 | .01 | .06 |
| ptsd01 | .01 | .01 | .86 | -.04 | .05 |
| ptsd02 | -.01 | -.01 | .93 | .03 | -.04 |
| ptsd03 | .00 | .02 | .84 | .00 | .01 |
| ptsd04 | .17 | -.02 | .47 | .06 | .09 |
| delusional | -.05 | .03 | .12 | .60 | .04 |
| hallucination | .03 | -.01 | -.04 | .83 | -.01 |
| sleep | .05 | .05 | .08 | .09 | .49 |
| focus | -.11 | .13 | .03 | .05 | .70 |
| stress | .14 | -.05 | .01 | -.03 | .74 |

**Table 3.** Reliability estimates for general and domain-specific factors

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Anxiety | Depression | PTSD | Psychosis | Psychophysiologic | P-score |
| omega | .86 | .91 | .90 | .71 | .78 | .95 |
| alpha | .86 | .91 | .90 | .70 | .78 | .93 |