3.4 Mental Health and Well-Being

According to the definition of the WHO, well-being is an important element of health. Impaired mental health is a major health issue in Western countries, for example, indicated by lifetime prevalence for mental disorders of 25% in Europe (Bruffaerts et al., 2011). These conditions are often accompanied by poorer quality of life and negative impacts on social and occupational domains. It has been shown that poor mental health also contributes to and can be associated with other physiological diseases and symptoms like diabetes (e.g. (Gilsanz et al., 2015), risk of stroke (Pan et al., 2010), or other cardiovascular diseases (Ladwig et al., 2017).

Although early research indicates an association between aircraft noise and mental health outcomes (Tarnopolsky, et al., 1980), the impact of environmental noise on mental health has not been in the focus of noise research for many years.

Mental health is often studied as part of health-related quality of life (HQoL) as a subject area (see D3.1). HQoL, again, is part of the quality of life (QoL), which in addition includes other aspects such as material living conditions, productive or main activity, education, leisure and social interactions, economic and physical safety, governance and basic rights, natural and living environment, and overall life satisfaction (e.g. EUROSTAT, 2017). HQoL is viewed as a multidimensional concept as it incorporates a person's physical health and psychological state "in a complex way" (WHO, 1995). Moreover, the WHO (1995) suggests health-related QoL to be the "individual's perception of his/her position in life in the context of the culture and value systems in which he/she lives in". The concepts of both well-being and HQoL are often used interchangeably, as they look at a person in his/her social environment, but they actually differ in that the concept of well-being focuses more generally on positive affect and satisfaction (Meiselman, 2016). Mental health, however, is well-being in a psychological manner, corresponding to emotional and cognitive functioning.

This review aims to identify relevant studies and research papers regarding the impact of aircraft noise on health-related quality of life, well-being and mental health. The following literature search was conducted giving an overview of the recent progress from 2014, and builds on the latest research, as represented in the review by Clark and Paunovic (2018). Starting with a summary of the latest systematic review on noise and mental health by Clark and Paunovic (2018) in section 3.4.1, section 3.4.2 gives an overview of the findings since 2014 regarding different aspects of mental health in terms of specific outcomes and different measuring methods.

3.4.1 Brief summary of results of the systematic review on noise and mental health by Clark and Paunovic for the WHO (2018)

The systematic review on the impact of environmental noise on health-related quality of life, well-being and mental health was performed by Clark and Paunovic (2018) with the aim of providing updated information for the revision of the WHO

environmental noise guidelines. It includes studies on noise from aircraft, rail traffic, and road traffic and wind turbines.

Studies with different kinds of measurement methods such as self-reported and interview measures were included. Literature published before 2005 had already been reviewed in existing systematic reviews, meaning that the WHO literature review of Clark and Paunovic (2018) focused on searches between 2005 and 2015. The studies were selected based on AMSTAR criteria: Assessing the Methodological Quality of Systematic Reviews (Shea et al., 2007). Due to methodological differences and the small number of studies found, a narrative systematic review was performed. The quality of examined studies and accompanying results were rated using the GRADE approach (Guyatt et al., 2008).

Overall, ten studies considering the impact of aircraft noise on mental health or quality of life outcomes were rated sufficiently according to AMSTAR criteria. Results reveal inconsistent findings. While five studies found no association between aircraft noise and poor self-reported QoL and health as well as well-being, respectively (Clark et al., 2012; Schreckenberg et al., 20101; Schreckenberg et al., 20102; Stansfeld et al., 2005; van Kempen et al., 2010), only the results of one study indicate an association between aircraft noise and lower mental health scores (Black et al., 2007).

Regarding medication use, one study found an association between daytime noise and prescription of anxiolytics but not for antidepressants (Floud et al., 2011). For measures of depression, anxiety and other psychological symptoms, no studies were available for self-reported measures; for interview measures, one study indicated an association between high aircraft noise exposure and anxiety disorders. The examined studies on emotional and conduct disorders also show no association with aircraft noise (Clark et al., 2012; Clark et al., 2013; Crombie et al., 2011; Stansfeld et al., 2005). Evidence for an association of aircraft noise exposure and hyperactivity in children is also inconsistent, with only two studies showing an association and one indicating no association (Crombie et al., 2011; Stansfeld et al., 2009).

Throughout the review, all evidence for associations and no associations were rated as being of low or very low quality. Estimates of risk cannot be drawn from the results of the review. The authors emphasise the difficulty in drawing conclusions from the studies for several reasons: the small number of studies, the differing study designs, and the wide variation of methods for both noise measures and outcome measurements. All these aspects hamper the comparability. They also state that studies do not consider confounding factors such as history of mental well-being, and other factors.

3.4.2 Updated review on aircraft noise and mental health since 2014

This review gives an overview of published studies since 2014 examining the relationship of aircraft noise exposure and mental health outcomes. The approach of the underlying literature search is described in Annex 7.1.5.

Table 8 gives essential information about the seven studies that met the inclusion criteria, showing a wide variation in terms of used exposure measures and outcome assessments. The studies are presented including sample size, country of implementation, utilised outcome measures and noise metrics as well as confounders and the information about a change situation. The latter is defined as a change in the noise situation occurring due to e.g. a constructional change at the noise source such as a new runway (van Kamp & Brown, 2013).

Most studies are implemented in the European region. In comparison to Clark and Paunovic (2018), no new studies considering emotional and conduct disorders in children, hyperactivity symptoms in children or studies examining medication intake or treatment of anxiety and depression, were found. Due to the small number of studies identified, this review is of a narrative nature.

Table 8: Description of aircraft noise and mental health studies since 2014

Outcome: self-reported (health-related) quality of life and well-being						
Author(s)	**N =**	**Country**	**Measurements**	**Confounder**	**Noise metric**	**Change**
Klatte et al, 2017	1,243	GER	Parents and children's ratings of quality of life Parents rating: KINDL-R (Fragebogen zur Erfassung et al, 1998) One subscale with 6 items for child mental well-being Children's rating: Well-being at school with 5 items	age, gender, SES (socio-economic status), classroom insulation, road-traffic noise, railway noise at school	$L_{AeqS08-14h}$ $L_{AeqA06-18h}$	Opening of new runway Night flight ban
Schreckenberg et al, 2017	3,508	GER	Mental health-related quality of life using SF-8	Mode of survey, gender, age, occupancy, hours out of home, ownership, socioeconomic status, migration background, noise sensitivity, body mass index, physical activity, noise levels for road and railway	L_{Aeq24h}	Opening of new runway Night flight ban
Fujiwara et al, 2017	Approx. 12,000	GB	Experience sample method Measure: well-being in two dimensions stating how happy and relaxed participants are Continuous scale from « extremely » to « not at all » with a slider	Land cover, distance from the coast, region and day of the week	Noise contours for aircraft noise above 57dBA (to 72dBA)	-
Lawton and Fujiwara, 2016	189,058	GB	4 ONS well-being questions - Life satisfaction «Overall, how satisfied are you with your life nowadays?» - Worthwhile «Overall, to what extent do you feel the things you do in your life are worthwhile?» - Happiness «Overall, how happy did you feel yesterday?» - Anxiety «Overall, how anxious did you feel yesterday?» Measured on an 11-point scale from 0-10 «not at all» to «completely»	Ethnicity, household income, health status, marital status, employment status, housing status, gender, age, geographic region, religion and education	L_{Aeq16h} L_{night} (above 55dBA for daytime noise, and 50dBA for night time noise)	-

Outcome: Self-reported depression, anxiety and psychological symptoms						
Author	**N =**	**Country**	**Measurements**	**Confounder**	**Noise metric**	**Change**
Hiroe et al., 2017	3,659	JAP	Total Health Index (THI) with 130 items; summing up to 12 subscales for mental health: - Mental instability - Depression - Nervousness 5 derived scores: e.g. 　　- Schizophrenics	Age, sex, noise sensitivity	L_{den}	Relaxation of restrictions
Baudin et al, 2018	1,244	FRA	- Single item: depressive symptoms (past 12 months) - General Health Questionnaire (12 items)	Age, country of birth, gender, occupational activity, alcohol consumption, smoking, number of stressful life events, income, antidepressant use	L_{den} L_{Aeq24h} $L_{Aeq06-22h}$ L_{night}	-
Outcome: Interview measures of depression and anxiety disorders						
Author	**N =**	**Country**	**Measurements**	**Confounder**	**Noise metric**	**Change**
Seidler et al, 2016	1,026,670	GER	Diagnosed unipolar depression (ICD-10)	Sex, age, urban living environment, unemployment benefits, SES	$L_{pAeq24h}$ $L_{pAeqnight}$	-

3.4.2.1   *Self-reported health-related quality of life and well-being*

Four studies assessed self-reported HQoL and well-being. Two of these assessed HQoL - one in children (Klatte et al., 2017), the other in adults (Lawton and Fujiwara, 2016). The other two studies investigated mental health-related QoL (Schreckenberg et al., 2017) and the effect of aircraft noise exposure on well-being (Fujiwara et al., 2017).

Fujiwara et al (2017) conducted a survey using the experience sampling method (ESM) examining momentary subjective well-being in and around British airports. In this study, data from a spatial positioning experience sampling (Mappiness) was merged with noise contour data from the GPS position of the participant. Results show that high levels of aircraft noise are associated with lower levels of happiness, with a significant negative association between aircraft noise at 66dBA (L_{eq}) and happiness and relaxation, respectively. Exposure to aircraft noise at 72dBA (L_{eq}) is also negatively associated with happiness ratings, but in a very small sub-sample.

Lawton and Fujiwara (2016) conducted a study using data from the national annual population survey (APS) in the UK to link well-being measures with aviation noise using noise contour data. In order to adapt the approach of experience sampling method, respondents were asked to rate their experienced well-being of the whole day. Significantly negative associations of daytime aircraft noise above 55dBL_{eq16hr} and all well-being measures were found, but with all confounders held constant each additional dB in daytime noise resulted in a marginal decrease of well-being measures. For nighttime noise levels no significant association was found.

In the section concerning self-related QoL, two sub-studies from the German NORAH study are included, one from the quality of life substudy and the other from the children sub study. In a longitudinal survey, Schreckenberg et al (2017) examined the association of aircraft noise exposure, annoyance and mental HQoL. Mental HQoL was assessed using the short form of the SF-36, the SF-8 (mental composite score, MCS). Results of the mental HQoL measures indicate that higher levels of aircraft noise are linked to poorer mental quality of life. A weak but significant impact of aircraft noise exposure on mental HQoL was revealed. They further investigated the causal relationship between noise exposure, noise annoyance and mental health-related quality of life (see D3.1).

The NORAH children study (Klatte et al., 2017) found small but significant effects of aircraft noise exposure on children's quality of life (measured with subscales of the standardised instrument KINDL) in a sample of 1,243 second-graders. Children's quality of life was assessed both via parents' ratings and children's ratings. Aircraft noise exposure was associated with less positive judgment of children's mental well-being and well-being at school.

The results of the examined studies suggest small negative effects of aircraft noise on self-reported QoL and well-being, for happiness and well-being only for people in high exposure areas. The two NORAH sub-studies show a decrease of health-related QoL with increasing aircraft sound levels.

In the studies by Lawton and Fujiwara (2016) and Fujiwara et al (2017), noise contour data were merged with other independent survey data to analyse the effects of aircraft noise on well-being measures. A benefit of this non-typical noise research method is that there is no anticipation of study objective in participants that might result in response bias. On the other hand, well-being and happiness are not standardised concepts used in noise research that can be compared to other results. Besides, in these studies only the current state of well-being is assessed, whereas in noise research usually long-term measures are used (e.g. annoyance is rated referring to the last 12 months) to predict long-term effects rather than acute effects of (aircraft) noise. In comparison, standardised scales (the SF-8 for adults and sub scaled of the KINDL for children) were used in the two NORAH studies; all of the studies analysed cross-sectional data.

In comparison to these reviewed studies, the studies analysed by Clark and Paunovic (2018) indicate that there is no association between aircraft noise exposure and measures of self-reported quality of life or health overall; this conclusion is based upon only one study out of six showing signs of an association.

In summary, the studies reviewed above suggest associations between aircraft noise exposure and mental health outcome measures, taking into account that these associations are weak.

3.4.2.2   Self-reported depression, anxiety and psychological symptoms
This particular literature search identified two studies assessing self-reported depression, anxiety and psychological symptoms.

To assess health effects in the vicinity of a major Japanese airport, Hiroe et al (2017) carried out a questionnaire survey in a sample of 3,659 residents using the Total Health Index (THI) questionnaire. The THI measures perceived physical and mental health via 130 items, which are added up to sub-scores (e.g. mental instability and depression referring to mental health). Results show a significant difference regarding depression scores between high exposure groups and the control group, but no exposure-response relationships between aircraft noise exposure and mental effects were found.

The French DEBATS study (Discussion on the health effects of aircraft noise) was performed to investigate the effect of long-term noise exposure from various noise sources on human health. The included sub-study assessed self-reported psychological symptoms using the General Health Questionnaire (GHQ) (12 items allowing identification of participants with psychological ill health) and one single

item asking for depressive symptoms in the past 12 months. Baudin et al (2018) report no association between exposure to aircraft noise and psychological distress regarding different noise levels and two types of psychological distress assessment.

The two studies reveal opposing effects for the impact of aircraft noise on psychological symptoms, but they also differ in used instruments operationalizing psychological symptoms. Baudin et al (2018) operationalized psychological health with a questionnaire using scores to group those with psychological ill-health and those with normal health, whereas Hiroe et al (2017) investigated psychological symptoms with a questionnaire deriving sub-scores for symptoms of depression and mental instability. In contrast to Hiroe et al (2017), Baudin et al (2018) focus on psychological distress in general. In comparison to Baudin et al (2018), who included a wide range of confounding factors, Hiroe et al. (2017) performed statistical adjustments for only a few potential confounders, namely noise sensitivity, age, sex and body-mass-index.

In the systematic review by Clark and Paunovic (2018) no studies addressing these outcomes have been identified.

3.4.2.3   Secondary data analysis of depressive and anxiety disorders

One of the NORAH sub-studies investigated depressive and anxiety disorders using secondary data, Seidler et al (2017) examined health insurance data of 1,026,670 residents living in the vicinity of Frankfurt International Airport. They analysed data regarding a relationship between aircraft noise exposure and diagnosed unipolar depressions. Due to the billing system in the German health care system, health insurance data only contains disorders and diseases diagnosed by specialists (psychotherapists and physicians). In this large case-control study, the authors found a relationship between aircraft noise exposure and diagnosed unipolar depression in an inverted u-shape with a peak of risk increase at 50-55dBA.

Since 2014, only one study that met the inclusion criteria examined risk for depression depending on aircraft noise exposure. Study results by Seidler et al (2017) contradict the findings in the study reviewed by Clark and Paunovic (2018) indicating no association between aircraft noise exposure and increased depression risk (Hardoy et al., 2005). Although in both studies trained physicians assessed a medically diagnosed depression disorder, the studies differ in terms of study quality; the main differences include the sample size and noise metrics.

The study carried out by Hardoy et al (2005) lacks a definition of the noise metric used, and the sample size is quite small. The study by Seidler et al (2017) however, shows that noise metrics are well defined and the sample size is large and controlled, which is seen to be a major strength. The study has its limitations however: only persons over the age of 40 years participated in the study, making applicability to younger people difficult.

3.4.3 Conclusions

The results of this review support the findings of the initial WHO review by Clark and Paunovic (2018) indicating inconsistent evidence for the influence of aircraft noise on mental health outcomes.

The small number of studies does not allow the derivation of exposure-response relationships and risk estimates, respectively. The variation in outcome measures limits the comparison of results and especially measures to assess HQoL. Moreover, psychological symptoms have to be differentiated from those detecting manifest disorders, as they do not necessarily lead to the development of severe disorders.

All the studies addressing self-reported HQoL reveal weak but significant associations providing evidence that health-related quality of life is impaired due to aircraft noise. One study sheds light on the link between aircraft noise and a diagnosed mental disorder, although no causal relationship can be established based on the data.

Mental health outcomes should be further addressed in aircraft noise research considering the association between annoyance due to aircraft noise and mental health outcomes that has been found in various studies (e.g. Baudin et al., 2018; Schreckenberg et al., 2017; D2.4 Section 4.4). Since it can be said that rising noise levels may lead to an increase in aircraft noise annoyance, it can be hypothesised that increasing annoyance levels might contribute to a decrease of QoL or increase in poor mental health. This seems to be particularly true at airports where residents expect negative changes in noise exposure, for example, due to an airport expansion (Schreckenberg et al., 2017).

To date, only little reliable evidence is found that considers the impact of absolute aircraft sound levels on mental health related outcomes. This might be different for the impact of (anticipated) relative changes in aircraft noise exposure on mental health. For now, other outcome measures should be addressed by noise mitigation and should be incorporated in intervention planning; preferably those that are related to mental health outcomes in order to potentially have an impact on those as well.

There is a dearth of studies exploring aircraft noise and mental health. The available evidence is relatively weak and further research would improve understanding of exposure-response relationships and risk estimates.