

1 **Interpretive Summary:**

2 (Adler) Do farmers' personalities and attitudes influence dairy cattle performance and
3 management? This review reports approaches and results.

4 The question of whether farmers as a person influence animal health, wellbeing, productivity
5 and management has received increasing attention over the past few decades. Attitude and
6 personality are psychological concepts characterizing such intrapersonal factors. The existing
7 literature on dairy cattle was reviewed to determine which approaches scientists have used to
8 answer the question of whether these concepts are such influencing factors. We show that
9 attitude and personality impact on outcomes but also identify aspects of research methods and
10 result presentations that hinder overall conclusions. This review may benefit scientists planning
11 future research and professionals considering mindset-aspects when working together with
12 farmers.

13

14 REVIEW: DAIRY FARMERS' PERSONALITIES AND ATTITUDES.

15 **Examining farmers' personalities and attitudes as possible risk factors for**
16 **dairy cattle health, welfare, productivity and farm management: A**
17 **systematic scoping review.**

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29 ABSTRACT

30 We aimed to determine how research regarding farmers' personalities and attitudes as risk
31 factors is reported (methodological approaches to assessing, extracting, and processing data and
32 analyzing risk factors) and to explore evidence for the impact of farmers' attitudes and
33 personalities on dairy cattle health, welfare, productivity and management. Therefore, we
34 conducted a systematic review to describe the spectrum of studies on personality and attitude
35 as risk factors for dairy cattle health, welfare, productivity and farm management. Database
36 searches captured 1144 records. 38 were finally included in the review. A tool to systematically
37 extract information was developed, pretested and used to assure the quality and entirety of the
38 extracted information. This review includes publications from 19 countries. Thirty-three
39 manuscripts assessed farmers' attitudes, one assessed their personalities and four assessed both
40 as risk factors. These potential risk factors were checked for relationships with more than 50
41 different outcome variables regarding farm management (seventeen manuscripts), animal
42 health (thirteen manuscripts), animal productivity (eleven manuscripts) and animal welfare
43 (four manuscripts). The approaches to assessing risk factors and processing and interpreting
44 data varied greatly; thus, drawing conclusions regarding the impacts of attitude and personality
45 as risk factors is impeded, as manuscripts are difficult to compare. Our findings highlight the
46 need for harmonization of attitudes and personality assessments in future research.
47 Furthermore, researchers should carefully consider which depth of detail to apply when
48 planning and evaluating related research. Nevertheless, results highlight the importance of the
49 impact of personality and attitude on outcomes. Farmers' personality and attitudes impact on
50 dairy cattle health, welfare, productivity and management. In general, attitudes indicating
51 higher degrees of technical knowledge, affection with problems, perceived responsibility,

52 perception of control of a situation , a better human-animal relationship or a positive evaluation
53 of the benefits of management decisions tended to impact in a beneficial way on outcomes.
54 "Agreeableness" and "conscientiousness" were shown promote better farm performance
55 whereas "neuroticism" impacted negatively. Therefore, further research on attitude and
56 personality and their consideration by professionals and decision-makers within the dairy sector
57 and politics is strongly recommended. This might provide the chance to better understand the
58 needs of dairy farmers and therefore develop tailored advice and support-strategies to improve
59 both satisfactory and constructive cooperation.

60

INTRODUCTION

61
62 Good stockmanship is necessary for optimization of health, welfare, husbandry and
63 management, thereby affecting physical and financial performance in animal production
64 (Beynon, 1991). This influence on animal performance in general can occur indirectly by
65 management decisions determining the conditions under which animals live or directly through
66 a certain human-animal-relationship which M.F. Seabrook already reported in 1972 when
67 investigating the cowmans' effect on milk yield in dairy cattle (Seabrook, 1972). The
68 investigation of human-animal-interactions has subsequently led to the construction of new
69 concepts such as human-animal-relationship (HAR) to describe the effects of humans on
70 animals as a part of animal welfare studies. HAR has become one of the most widely used
71 concepts with respect to explaining human influence on animal welfare. It is based on the
72 assumption that animals fear humans (Hemsworth, 2003). The level of fear in farmed animals
73 has been shown to impact on their performance for various species (Hemsworth et al. 1981;
74 Barnett et al., 1992; Cransberg et al. 2000; Hemsworth et al.; 2000). It has also been shown that
75 the way stockpeople interact with their animals has strong effects on the level of stress and fear
76 animals experience (Hemsworth et al., 1989; Jones, 1993). Today, stockmanship, in general, is
77 proposed to consist of three essential traits: animal husbandry knowledge, animal husbandry
78 skills and personal qualities (Department for Environment, 2007). The fact that personal
79 qualities are seen as a main trait of stockmanship is a result of researchers, in addition to the
80 investigation of environmental risk factors, paying increasing attention to the farmers or
81 stockpersons themselves regarding their influence on farm animal well-being and performance
82 (Beynon, 1991). Hence, it is important to understand which person-intrinsic determinants might
83 lead to farmers deciding or acting in a certain way; socio-psychological approaches have
84 therefore emerged in veterinary and animal science research. These approaches assess human-
85 intrinsic influences, including personal qualities. However, within this research, diverse terms
86 have been used to characterize these personal qualities of interest. "Personal characteristics"

87 (Waiblinger et al., 2002), “ethical positions” (de Rooij et al., 2010), “empathy” (Kielland et al.,
88 2010), “perceptions” (Vaarst and Sorensen, 2009), “mindset” (Scherpenzeel et al., 2016),
89 “attitude” (Bruijnis et al., 2013) and “personality” (Hanna et al., 2009). This diversity reflects
90 underlying variation, including:

- 91 - Use of different approaches to capture the stockmen's personal qualities.
- 92 - Different theoretical backgrounds underpinning exploration of the concepts of farmer-
93 intrinsic risk factors.
- 94 - Knowledge of assessment methods and results interpretation are required to evaluate
95 the significance of the findings and the importance of stockman-intrinsic risk factors.

96 Existing literature revealed that the psychological concepts, “personality” and “attitude”, were
97 consistently used to label personal qualities. Several socio-psychological research publications
98 were available regarding these concepts' theoretical backgrounds. In preparing for a nationwide
99 cross-sectional study on dairy herd health and performance we therefore focused on these two
100 concepts to investigate how they impact on dairy cattle health, welfare, productivity and farm
101 management.

102 Prior to assessing the impact of attitude and personality on these outcome themes it is important
103 to define and describe the theoretical backgrounds of these concepts:

104 **Personality** refers to individual differences in characteristic patterns of thinking, feeling and
105 behaving (adapted from Encyclopedia of Psychology). Personality psychology is “the study of
106 what makes a person unique from others” (Feist, 1998). In contrast to attitude measures, which
107 are context dependent (Schwarz, 2001), personality traits remain relatively stable after a person
108 reaches age 30 (Costa, 1994). Psychologists capture human personality in predefined domains,
109 which have been characterized in lexical studies, which identify the most salient aspects of
110 human personality based on these aspect's representation in a language's lexicon (Saucier,
111 2001). The names and numbers of domains and subordinate facets finally representing human

112 personality differ depending on the framework considered. For example, the Big-Five
113 framework is popular and is the most widely used and extensively researched personality
114 model. This framework classifies individual personality differences into five broad empirically
115 derived domains (Gosling et al., 2003). Each domain includes six subordinate facets.

116 In contrast to the Big-Five framework, other researchers argue that a six-factor-structure better
117 describes personality variations (de Vries et al., 2016); thus, the HEXACO-model was
118 developed. However, regardless of the overall number of domains and facets included in a
119 framework, psychologists have shown that personality dimensions can predict human behaviors
120 such as health behavior (Booth-Kewley, 1994). Irrespective of the framework considered,
121 approaches to assessments are the same; respondents are provided with a number of descriptive
122 statements to rate on a Likert Scale in most validated inventories.

123 **Attitude**, however, represents a summary evaluation of a psychological object (Ajzen and
124 Fishbein, 2000). Psychological objects are the objects that psychologists choose to investigate
125 (Danziger, 1993). This expression is therefore used synonymously for "attitude object" here.
126 Every attitude must be related to one specific psychological object (Ajzen, 2001). In assessing
127 attitude, psychological objects can be physical objects (e.g., dairy cows), theoretical questions
128 (e.g., importance of calf-rearing practices) or behavioral options (e.g., adopting certain farm
129 management practices). Assessment of a person's attitude towards an object requires that the
130 object is presented to that person for evaluation. This can be done by direct and indirect
131 measurement. A common approach to direct measurement is to provide the respondent with
132 statements related to the attitude object. The respondent would then agree or disagree with that
133 statement using a Likert or semantic differential scale. Indirect measurements use projective
134 techniques, presenting the person with ambiguous or incomplete stimuli (e.g., pictures or open-
135 ended qualitative interview questions) that require interpretation or lead to narrative material
136 around the psychological object of interest. The person's attitude is then inferred by how they

137 respond (McLeod, 2009). In both direct and indirect measurement, the researcher must extract
138 and interpret the attitude information by applying suitable data processing and analysis
139 techniques.

140 Attitude is an important research area, as attitudes can predict behavior (Ajzen, 2001). Two
141 prominent theoretical frameworks underpinning this are the Theory of Reasoned Action (TRA)
142 and the Theory of Planned Behavior (TPB; Ajzen, 1985; Kauppinen et al., 2013). However,
143 another important aspect is that attitudes can change; motivation and capacity are assumed to
144 be required for such a change (Wilson et al., 2000). Farmers' attitudes, therefore, are potential
145 targets for external stimuli (e.g., veterinary consultancy, intervention programs) aiming to
146 change behavior to improve the animals' situation or farm productivity. For example, the
147 positive effect of a cognitive behavioral intervention program on attitude and behavior of dairy
148 stockpeople has been reported by Hemsworth et al. (2002).

149 In order to investigate the impact of personality and attitudes on dairy cattle health, welfare,
150 productivity and farm management, we conducted a systematic scoping review of the related
151 literature. In contrast to a systematic reviews seek to appraise and synthesis research evidence,
152 scoping reviews aim to assess and identify the scope and nature of research related to a specific
153 topic (Grant et al., 2009). The review was conducted focusing on three objectives:

154 (1) Describe the **spectrum of studies on personality and attitude as risk factors** for dairy
155 cattle health, welfare, productivity and farm management.

156 (2) Describe **whether risk factors (personality and attitude) are related to (which)**
157 **dependent variables.**

158 (3) Examine whether **overall contextual conclusions** can be drawn on the impact of farmers'
159 attitudes and personalities on dairy cattle health, welfare, productivity and management.

161 Based on PRISMA-statement recommendations (Liberati et al., 2009) and guidelines proposed
162 for conducting scoping reviews (Colquhoun et al., 2014; Peters et al., 2015) the existing
163 literature was systematically reviewed to provide a structured overview of research on farmers'
164 personalities and attitudes as risk factors for dairy cattle health, welfare, productivity and
165 management. The review was focused only on the risk factor analyses that consider personality
166 and/or attitude as (human) risk factors for an outcome related to animal health, welfare,
167 productivity and management conditions. Welfare is a multidimensional term including an
168 animals' physical and mental state defined by the "five freedoms" (Department of environment,
169 2007). From this perspective it might also cover aspects related to other thematic areas of
170 dependent variables (i.e. health, productivity). Nevertheless, for this review, it was decided to
171 consider "health" and "productivity" as independent thematic areas for the purpose of clear
172 discrimination and to be able to define eligibility criteria (see below). We did not perform a
173 meta-analysis due to the wide scope of our approach. Furthermore, we did not focus on
174 intervention strategies associated with personality and attitude; this would be a useful second
175 step after identification of the role of personality and attitude traits as risk factors. Instead, we
176 describe the scope of research and general findings and present aspects related to
177 methodological approaches and results presentation and interpretation which may be
178 considered in future research.

179 *Search and extraction strategy*

180 **Eligibility criteria** were defined prior to the study. The review includes peer-reviewed journal
181 articles on dairy cattle of all breeds and ages. Languages were limited to English and German.
182 Geography and publication year were not restricted. Personality or attitude had to be explicitly
183 mentioned in the title, abstract or keywords and had to be reported as risk factors for one or
184 more dependent outcomes of interest. Specifically, dependent variables had to be related to
185 animal health (e.g., disease prevalence, somatic cell counts), productivity (e.g., milk yield, milk
186 contents), farm management (e.g., on-farm management decisions and farmers' behaviors

187 towards animals) and welfare. Welfare in the context of this review covers the animals' mental
188 state (e.g., aversive behavior indicating stress). Assessments had to be performed by clinical
189 examination or scoring the animals or evaluation of their behavior, the farmers' behavior, farm-
190 performance data, data collected by the farmers on the farm, pre-existing data from external
191 sources (e.g., health monitoring programs) or assessing information from questionnaires or
192 interviews.

193 Web of science, PubMed and CAB Abstracts were used as search databases. Searches were
194 performed in German and English.

195 The **search strategy** was identical for all three databases. Known relevant literature was used
196 to develop search-strings. Sensitivity analysis was performed by testing different combinations
197 of concepts and keywords in all three databases. Concepts were modified by the outcome to
198 make sure all relevant literature was captured. Terms which did not contribute to improvement
199 of the queries were dismissed. For example, terms included in explorative searches like
200 "cowman" and "animal-keeper" (concept I) and "trait*" (concept II) were removed as they did
201 not improve search performance.

202 Tables 1 and 2 indicate the final search-concepts and keywords included in the search strings.
203 The final search in English was conducted on 24 April 2017 (Web of Science, Pub Med and
204 CAB Abstracts up from 1989) and on 10 May 2017 for CAB Abstracts 1910-1989. The final
205 search in German was conducted on 10 May 2017 in all three databases. By the end of the
206 revision process, an update was performed running the search in all three databases once more
207 on 5 December 2018.

208 **Study selection** was performed in three stages. First, the title, abstract and keywords from the
209 papers captured by the final database searches were screened. The terms "personality" or
210 "attitude" or both had to be explicitly mentioned and considered potential influencing factors.
211 Outcome variables had to be related to dairy cattle health, welfare, productivity or farm

212 management. Second, after removing duplicates, full texts were then checked for relevance in
213 detail. Finally, reference lists of the eligible papers were checked for potential missing records.

214 We developed an a priori data sheet to **extract information** from the included full texts, using
215 Microsoft ExcelTM (Redmond, WA, USA). The sheet was piloted by the first author on five
216 randomly-selected included papers and refined accordingly until the data sheet captured all
217 pertinent information relating to the review's objectives. To prevent observer bias, data were
218 extracted independently and in duplicate by the first author and two colleagues. Differences in
219 extracted information were discussed by involving the last author to reach consensus.

220 *Extracted information*

221 The final data sheet consisted of 22 items. Three were included to internally manage data
222 ("consecutive number of the record", "record included in data extraction" [yes or no] and
223 "record's citation").

224 To describe the **study spectra on personality and attitude as risk factors**, descriptive
225 characteristics of the published research were extracted: "country of research", "personality
226 assessed" (yes or no), "attitude assessed" (yes or no) and "dependent variables assessed". Per
227 the predefined dependent variable categories, the "dependent variable category" (health,
228 welfare, productivity, or management) was extracted. Whether the "theoretical framework for
229 personality or attitude [was] explicitly named" (yes or no) was documented. Furthermore, the
230 methodological approaches to assessing personality ("personality model applied or facets
231 assessed", "instrument used to assess personality") and attitude ("instrument used to assess
232 attitude", "attitude-items considered individually or attitude-classes generated", "attitude
233 classes assessed or extracted from the items", "statistical method for generating attitude-class"
234 and "method used to analyze risk factors" were documented. "Number of items and scales
235 provided" was extracted concerning the assessment of personality and attitude. As attitudes are
236 connected to specific psychological objects (Ajzen, 2001), this was extracted as well

237 (“psychological object”). At this point, the exact wording used to label the psychological
238 objects was extracted from the records without adding any interpretation concerning their
239 meaning. Subsequently, psychological objects were aggregated into generic terms and topics.

240 To determine **whether risk factors (personality and attitude) are related to (which)**
241 **dependent variables**, “relationship between attitude and dependent variable” and “relationship
242 between personality and dependent variable” (yes or no) were extracted.

243 We assessed possible factors that may hinder an **overall conclusion** on the impact of attitudes
244 and personality. Focus was on data collection and processing (e.g., summing up information on
245 attitude or personality in scores or latent data) and on conducting risk factor analyses.
246 Additionally, the disclosure of questions/items used for risk factor analyses was assessed
247 (“Items used for personality assessment made accessible” [yes or no] and “Items used for
248 attitude assessment made accessible” [yes or no]).

249 **RESULTS**

250 *Spectrum of studies on personality and attitude as risk factors*

251 In total, 1144 records were captured by the search strategy. Figure 1 illustrates the paper
252 selection steps and the number of studies excluded at each step. The main reasons for excluding
253 records were: (1) presenting only descriptive results on personality and attitude, (2) considering
254 attitude as an outcome, (3) considering outcomes, which were not meeting the eligibility criteria
255 (4), investigating effects of intervention aiming to change attitudes and (5) dealing with beef
256 cattle.

257 In all, 38 records meeting eligibility criteria were identified and included in the review. The
258 completed data extraction sheet can be accessed as supplementary material (Supplemental
259 Table S1; <http://dx.doi.org/10.3186/jds.20XX-XXXXX>). Publication years ranged from 1972
260 (Seabrook, 1972) to 2017 (DeLong et al, 2017; Kayitsinga et al., 2017). Most publications

261 assessed attitudes as risk factors (n=33; 86.8%), four publications assessed attitude and
262 personality (n=4; 10.5%) and one assessed personality only (n=1; 2.6%). Research on the
263 effects of farmers' personalities and attitudes on dairy cattle health, welfare, productivity and
264 management as far as captured by this review includes data from 19 different countries. Half of
265 this research was conducted in the United Kingdom, the Netherlands and Norway (n=19; 50%;
266 Table 3). The dependent variables were related to dairy cattle health (n=13 publications),
267 welfare (n=4), productivity (n=11) and farm management (n=17).

268 ***Theoretical background.*** Four of five papers investigating **personality** presented at
269 least basic information on the theoretical background underpinning their assessment. Three of
270 five articles referred to the Big-Five personality traits as a basis for their assessment. Waiblinger
271 et al. (2002) and Seabrook (1972) indicated no specific theoretical background behind their
272 personality assessment. Only Alvarez and Nuthall (2006) presented explicit theoretical
273 backgrounds on the relationship between personality and outcome variables, referring to the
274 Information Innovation Adoption Model (Agarwal and Prasad, 1998).

275 Theoretical background for assessing **attitude** grounded in socio-psychological research was
276 provided in 48.7% (n=18) of the papers. Theoretical backgrounds explicitly mentioned were
277 the Theory of Planned Behavior (n=5), Theory of Reasoned Action (n=5), Health Belief Model
278 (n=1), Behavioral Economics (n=1) and Social Ecology Model (n=1). Two papers referred to
279 more than one theory. Papers not explicitly mentioning the theoretical background behind their
280 research provided citations leading to corresponding social science information (n=6). Finally,
281 50% (n=17) of papers provided no information on the socio-psychological background.

282 ***Data collection.*** Four of five studies assessing farmers' **personalities** employed self-
283 report questionnaires. Within the publications included (n=5), eleven personality domains were
284 assessed (Table 4). For that purpose, Hanna et al. (2009) obtained a questionnaire from the
285 International Personality Item Pool (<http://ipip.ori.org>; 2001), while Arias and Spinka (2005)

286 employed the Czech standard short version of the NEO Big-Five Personality Inventory adapted
287 from Costa (1992). Alvarez and Nuthall (2006) employed a locally developed item set to assess
288 the Big-Five personality domains. Waiblinger et al. (2002) and Seabrook (1972) did not use a
289 conventional personality test but rather a self-developed item set. All questionnaires, except the
290 one used by Seabrook (1972), included a set of statements to be rated by the respondent. Each
291 statement coded for one specific personality domain only; however, each domain could be
292 assessed through several statements. The number of statements coding for a domain depended
293 on the questionnaire. To rate the items, Hanna et al. (2009) and Arias and Spinka (2005)
294 provided Likert scales to the respondents. Waiblinger et al. (2002) operated a semantic
295 differential scale. Alvarez and Nuthall (2006) did not report the scale used to rate the
296 questionnaire items. Seabrook (1972) initially provided respondents with questions during
297 structured interviews, however this approach, turned proved to be inappropriate when piloting
298 it. Consequently, an approach based on the "play technique" was used.

299 Psychological objects were of interest in assessing attitudes. Given that exact wording was
300 taken as presented in the papers without interpreting textual meanings, 35 psychological objects
301 were assessed. Fourteen studies (37.8%) reported to have investigated attitudes towards more
302 than one psychological object. Most studies investigated attitudes towards animal diseases, their
303 diagnostics and therapy (n=20; Table 5).

304 Twenty-five papers (67.6%) reported having used questionnaires completed by respondents.
305 Questionnaires were completed in person during farm visits (n=11) or sent to respondents by
306 post (n=9) or email (n=1). In one further study, respondents could answer the questionnaire
307 online only, and three other papers reportedly let the respondent decide whether to answer on
308 paper or online.

309 Eleven papers (29.7%) used interviews to investigate attitudes. Nine (81.8%) conducted
310 interview questionnaires face-to-face (n=5) or via telephone (n=4). Two papers (18%) reported

311 using semi-structured face-to-face interview techniques. One paper reported conducting farm
312 visits and studying stockpeople based on the "play technique" (Seabrook, 1972).

313 The number of items presented to the respondents ranged from a single item to 157 (Waiblinger
314 et al., 2002). Seven papers (18.9%) did not indicate the number of items included. Based on
315 existing information, the average number of items was 24. For quantitative approaches, Likert
316 scales were used most frequently (91%; n=31 papers). In one study (Alemayehu et al., 2010),
317 researchers asked respondents to answer a question on a binary (yes/no) scale. Two papers (6%)
318 did not indicate which scale was used.

319 Interviewees' responses to open-ended questions included in qualitative interviews were audio
320 recorded and transcribed word-for-word to extract subsequent information (Heffernan et al.,
321 2008; Vaarst and Sorensen, 2009).

322 *Item disclosure.* No papers provided the complete wording of the items used to assess
323 **personality** data. Two papers referenced these items by citing other studies or technical
324 literature (Arias and Spinka, 2005; Alvarez and Nuthall, 2006). Hanna et al. (2009) presented a
325 web link to the questionnaire used; however, this link was inactive when we tried it. Waiblinger
326 et al. (2002) provided one example from the 14 statements they used to assess personality.

327 Twenty papers (54%) that investigated farmers' **attitudes** disclosed all items in text or tables
328 (n=19) or in supplementary material (n=1). Seventeen (46%) provided no comprehensive
329 information on the items used. One paper (Schewe et al., 2015) included a web link for that
330 purpose; however, it was inactive at the time this review was undertaken.

331 *Information extraction and data processing.* Information on extracting **personality**
332 dimensions and processing data to assess personality was presented in two of five publications
333 (Waiblinger et al., 2002; Arias and Spinka, 2005). Arias and Spinka (2005) provided stock-
334 people with a questionnaire containing 60 self-description items to rate on a five-degree scale,

335 ranging from “fully agree” to “fully disagree”. Twelve items represented each personality
336 dimension. To measure each of the four dimensions, the average score was calculated from the
337 twelve items coding that dimension. Waiblinger et al. (2002) used Principle Component
338 Analysis and Varimax Rotation to reduce the 14 self-descriptive items in their questionnaire.
339 The result was three components representing personality dimensions, which were labelled as
340 “agreeable”, “confident-extravert” and “pessimistic”.

341 **Attitude** information extraction and data processing methods differed between studies
342 depending on the technique used to obtain the primary data. Two major approaches to extracting
343 attitude information in quantitative research were found. Twenty-five papers (73.7%)
344 condensed items into smaller numbers of attitudes classes or into an overall attitude. Six
345 (17.7%) considered each questionnaire item in the risk factor analysis. Two papers (5.8%)
346 combined both approaches. One paper (Bertenshaw and Rowlinson, 2009) provided no
347 comprehensible information on information extraction.

348 Principle component analysis (PCA) was the most common procedure for condensing attitude
349 items (52%; n=13), followed by summing single item scores to calculate a final attitude score
350 (16%; n=4). Other papers used procedures such as factor analysis (Vande Velde et al., 2015;
351 Fukasawa et al., 2016), structural equation measurement models (Toma et al., 2013; Toma et
352 al., 2015) or transforming a five-point Likert scale into a dichotomous outcome (Kielland et al.,
353 2010).

354 Content analysis (Heffernan et al., 2008) and a modified grounded theory approach (Vaarst and
355 Sorensen, 2009) were used to code information from semi-structured interviews. Seabrook
356 (1972) used records (e.g. percentage distribution of comments made by stockmen, stockman
357 cow interactions) to extract attitude information by comparing the different stockmen.

358 **Risk factor analysis.** After extracting **personality** dimensions, risk factor analysis was
359 conducted using Spearman correlation (Waiblinger et al., 2002; Arias and Spinka, 2005) and
360 partial correlation analysis (Hanna et al., 2009). Alvarez and Nuthall (2006) looked for direct
361 relationships between personality dimensions and outcome variables by the t-test, Mann-
362 Whitney U test and Chi-square test. Only variables directly affecting the outcome variables
363 were included in a structural equation model. Correlation coefficients or standardized
364 regression weights were used to investigate relationships between personality dimensions and
365 outcome variables.

366 Diverse statistical methods were used to analyze risk factors investigating **attitudes**.
367 Correlational analysis (e.g., Spearman correlation, Pearson correlation, and partial correlation
368 analysis) and regression analysis (e.g., linear regression, logistic regression, and regression tree
369 analysis) were the most frequently mentioned approaches, followed by structural equation
370 modeling.

371 Vaarst and Sorensen (2009) conducted semi-structured qualitative interviews to assess
372 attitudes, using modified grounded theory to extract attitude themes. They compared two groups
373 of farms (high versus low calf mortality) relative to the attitude themes farmers mentioned
374 during their interviews. Related conformities and differences were analyzed to evaluate the
375 impact of attitude on calf mortality.

376 ***Relationship between personality and dairy cattle health, welfare, productivity and*** 377 ***management***

378 Three of the five studies assessing farmers' **personalities** reported it to be at least partially
379 related to the dependent variables. When Waiblinger et al. (2002) assessed three personality
380 components ("agreeable", "confident-extravert", and "pessimistic"), only "agreeableness" was
381 significantly negatively correlated with the percentage of farmers' neutral and negative
382 behaviors towards cows. In contrast, "agreeableness" was positively correlated with farmers'

383 positive behaviors towards cows during milking. Arias and Spinka (2005) reported that
384 “neuroticism” in stock-people was negatively correlated with average herd milk yield in kg per
385 standardized lactation, and also positively correlated with mean veterinary care costs per dairy
386 cow and year on the farm. Neuroticism, here, is defined as emotional lability (Roccas et al.,
387 2002). This dimension can be divided into six facets (anxiety, anger, depression, self-
388 conscientiousness, immoderation and vulnerability).

389 Conversely, “conscientiousness” was negatively correlated with veterinary costs. This
390 dimension comprises the facets self-efficacy, orderliness, dutifulness, achievement striving,
391 self-discipline and cautiousness thus representing a persons' tendency to be careful or vigilant
392 (Roccas et al., 2002). Seabrook (1972) found the personality of stockmen to impact on milk
393 yield and suggested that this was because some farmers achieved a better human-animal
394 relationship on their farms.

395 Although they assessed the same Big-Five personality traits as Arias and Spinka (2005), Hanna
396 et al. (2009) identified no relevant direct correlation between personality domains and milk
397 yield. Furthermore, Alvarez and Nuthall (2006) revealed no relevant direct relation between
398 personality domains and farmers adopting computer-based information systems.

399 *Relationship between attitudes and dairy cattle health, welfare, productivity, and* 400 *management*

401 Table 6 provides an overview of reported relationships between dependent variables sorted by
402 thematic areas and **attitudes**. Extracting the exact wording for psychological objects from the
403 records led to diverse combinations of attitudes and dependent variables. Therefore, it was
404 impossible to determine reported relationships between all dependent variables and attitudes.
405 More than 50 dependent variables were investigated overall. Four of 37 papers (10.8%) found
406 no relevant relationships between attitude and dependent variables. In the following, despite
407 differing methodological approaches, we highlight findings on attitudes' impact from the

408 reviewed studies within the different thematic outcome areas. These will be discussed later on
409 concerning their possible consideration for future research or professionals in the field.

410 ***Impact of attitudes on animal health.*** The impact of attitudes on milk **somatic cell counts** was
411 investigated within various studies. Schewe et al. (2015) and Jansen et al. (2009) showed that
412 somatic cell counts were associated with farmers' attitudes towards mastitis. Higher cell counts
413 were shown to be positively associated with the farmer seeing mastitis and not following
414 milking- and treatment protocols as a problem on his farm (Schewe et al., 2015). Furthermore,
415 the farmers' perception of control over the problem was revealed to be negatively correlated
416 with cell counts (Jansen et al., 2009; DeLong et al., 2017) and the incidence of clinical and
417 subclinical mastitis (DeLong et al., 2017). In addition, Tarabla and Dodd (1990) showed that
418 farms on which the stockperson evaluated the task of milking as positive (i.e. positive attitude
419 towards milking) were less likely to show high cell counts.

420 A positive attitude towards **calf mortality** and **calf disease** (i.e. the farmer feeling in control of
421 the situation) was shown to negatively impact on farms' calf mortality rates (Vaarst & Sorensen,
422 2009). Santman-Berends et al. (2014) revealed that farmers who reported to see a dead calf as
423 a problem to have lower mortality rates and those considering a stillbirth from a cow more
424 severe than a stillbirth from a heifer to have higher rates. Silverlas et al. (2013) found an
425 association between positive attitudes towards biosecurity (i.e. considering biosecurity as
426 important) and lower **cryptosporidial** prevalence in calves on farms. Kielland et al. (2010)
427 investigated the impact of farmers' attitudes towards pain in cattle on the prevalence of **lesions**
428 **on the hock and carpus of cows**. Farmers indicating agreement to the statement "animals feel
429 pain as humans do" were more likely to have low prevalence of hock and carpus lesions on
430 their farms. Furthermore, the prevalence of **lame cows** was shown to correlate with attitudes
431 towards cows (Rouha-Mulleder et al., 2009). Prevalence increased with farmers indicating a
432 higher intention to use negative behavior when moving cows and decreased with farmers'

433 reporting dislike of such negative behavior. Broughan et al. (2016) showed the odds of being
434 a **bovine tuberculosis (bTB) case** to be associated with farmers' attitudes towards bTB.
435 Farmers' seeing their animals less under threat of other cattle as possible carriers of the disease
436 and being less likely to think that other people or institutions could help them to solve the
437 problem of bTB had higher odds to be a case farm.

438 *Impact of attitudes on welfare.* The impact of stockpersons' attitudes on dairy cattle welfare
439 was investigated by studying the behavior of cows in presence of humans. Assessing the impact
440 of stockpersons' attitudes towards "characteristics of cows" and "working with dairy cows",
441 Breuer et al. (2000) reported that positive attitudes towards cows were negatively correlated
442 with **aversive cow behavior** (i.e. flinch-, step- and kick-responses) in the milking parlor. De
443 Roches et al. (2016) revealed that farmers with a more negative behavioral attitude towards
444 cows had a lower proportion of **cows accepting to be touched** in a standardized avoidance
445 distance test.

446 *Impact of attitudes on productivity.* **Milk yield** and **milk contents** were investigated
447 concerning their relation to farmers' attitudes in various studies. Attitudes towards cows (i.e.
448 cows' characteristics and working with dairy cows) were the psychological objects used most
449 frequently within this research area. Employing the same questionnaire items and answer scales
450 to assess attitudes, Hanna et al. (2009) extracted four factors ("empathy", "negative beliefs",
451 "job satisfaction" and "patience") from the raw data, whereas Fukasawa et al. (2017) extracted
452 only three ("positive beliefs", "negative beliefs" and "job satisfaction"). Risk factor analysis
453 findings also differed. Fukasawa et al. (2017) found only "positive beliefs" to be positively
454 related to milk yield. In contrast, while Hanna et al. (2009) found the attitude classes, "empathy"
455 and "job satisfaction", to be positively correlated with milk yield, no such correlation was found
456 for milk yield and "patience". "Negative beliefs", however, negatively impacted on milk yield.
457 The association between job satisfaction and milk yield is in compliance with Seabrook (1972)

458 who found attitudinal factors related to job satisfaction (i.e. perceived level of stress, motives,
459 emotion) to be associated with milk yield. Breuer et al. (2000) found a positive composite
460 attitude towards cows (including items related to petting and talking to cows, ease of movement
461 of cows and the ability of cows to recognize unfamiliar stockpeople) to be positively correlated
462 with milk yield and protein contents, while Kauppinen et al. (2013) did not find any associations
463 between farmers attitude towards improving animal welfare and milk yield. Nor did Arias and
464 Spinka (2005) reveal any associations between farmers' attitudes towards dairy cows and
465 productivity.

466 *Attitude and farm management.* Bruijnjs et al. (2017) found farmers' positive attitude towards
467 the belief that foot health could really be improved by taking action to be positively correlated
468 with their reported intention to improve cow foot health. Toma et al. (2015) aimed to identify
469 attitudes modulating farmers' behavioral willingness to control **E. Coli infections** on their
470 farms. Knowledge about the pathogen, the feeling of responsibility and former experience with
471 related infections on the farm were identified to be drivers that positively impacted on farmers'
472 willingness to take action. Conversely, Heffernan et al. (2008) did not reveal any
473 comprehensible relationship between attitudes towards individual versus collective **biosecurity**
474 **behavior** and attitudes towards biosecurity regulation and participation in bio-security
475 collective action among farmers. Also related to the biosecurity aspect, Ritter et al (2015)
476 investigated whether farmers participated in a voluntary management-based **Johne's disease**
477 control program. Attitudes towards the disease and the control program were considered
478 potential influencing factors. The results showed participants to have higher self-assessed
479 knowledge of Johne's disease and better understanding of the control programs' details. Non-
480 participants' attitudes indicated time to be a major on-farm constraint and those farmers stated
481 that participation in the program would take them too much time.

482 Other research was concerned with management decisions related to therapy of diseases and
483 drug use. The impact of farmers' attitudes towards **mastitis** and employee training on the
484 frequency of mastitis-related antibiotic drug use (intramammary; IMA and systemic; SYA) was
485 investigated by Kayitsinga et al. (2017). Their results showed that farmers who believed that
486 "bad luck" plays an important role in mastitis problems were more likely to apply IMA and
487 farmers who financially penalized their employees in case of increased cell counts were more
488 likely to apply SYA. Scherpenzeel et al. (2016) found that attitudes towards dry cow therapy
489 and reduction of antibiotic usage in the animal industry were related to whether farmers were
490 performing selective dry cow treatment (SDCT) instead of blanket dry cow treatment (BDCT)
491 on their farms. Three attitudinal variables were found to impact on this decision: The beliefs
492 that financial consequences was one of the most important negative aspects of reducing
493 antibiotic usage and uncertainty whether a cow would recover from mastitis without
494 antimicrobials were both related to a higher odds that farmers were applying BDCT on their
495 farms. Similarly, Jones et al. (2015) investigated farmers' intention to reduce on-farm antibiotic
496 usage over the next twelve month. Although the calculated overall attitude did not show to be
497 related, single aspects like thinking that reducing antibiotic usage would be a good thing, would
498 lower the costs and would increase consumer confidence in milk and milk products correlated
499 positively with intention to reduce antibiotic usage. Vande Velde et al. (2015) found farmers'
500 attitudes towards "anthelmintic drugs" and "nematode diagnostic methods" to be associated
501 with farmers' intention to adopt **diagnostic methods before implementing anthelmintic**
502 **drugs**. Negative attitudes towards diagnostics (constructed of the items Good-Bad, Useful-
503 Useless and Beneficial-Harmful) showed to be negatively associated with uptake of
504 diagnostics, while positive attitudes towards the use of anthelmintic drugs impacted positively
505 on intention to perform previous diagnostics.

506 Investigating the impact of attitudes on human-animal-relationship Hemsworth et al. (2000)
507 and Breuer et al. (2000) investigated the impact of farmers' attitudes towards **dairy cows on**

508 **human behavior during milking.** Breuer et al. (2000) found that positive attitudes were
509 negatively correlated with the percentage of highly negative tactile interaction during milking
510 and positively correlated with the proportion of quiet and soft vocalizations of farmers.
511 Hemsworth et al. (2000) also revealed that stockpeoples' positive attitudes towards the behavior
512 of dairy cows correlated negatively with the number of forceful tactile interactions during cow
513 handling.

514 Concerning investigation of the uptake of general management aspects on dairy farms,
515 Alemayehu et al. (2010) reported that Ethiopian farmers' preferable attitudes towards the
516 production of indigenous Horo cattle was a determinant for the decision to choose that marked-
517 oriented business. Questioning which factors might influence the adoption of improved
518 grassland management among small-scale dairy farmers in Mexico, Martinez-Garcia et al.
519 (2013) reported that positive attitudes towards that option (i.e. decrease of costs, increase of
520 milk yield, easy to manage) promoted the uptake whereas negative attitudes (e.g. requires
521 availability of land, investments are not recovers from milk sales) prevented farmers from using
522 improved grassland. Using the same questionnaire items for attitude assessment and theoretical
523 framework (i.e. Theory of reasoned action), Garforth et al. (2006) and Rehman et al. (2007),
524 both showed that farmers' positive attitudes towards different approaches to better oestrus
525 detection (e.g. cost effectiveness, better detection rates) lead to a higher intention to adopt
526 recommended observation times, milk-progesterone test kits and use of pedometers on their
527 farms.

528 **DISCUSSION**

529 Here, we have systematically reviewed research considering farmers' personality and attitudes
530 as risk factors for dairy cattle health, welfare, productivity and farm management. Focus was
531 on methodological approaches and whether overall contextual conclusions can be drawn on
532 personalities' and attitudes' impact on outcome variables. We found methodological

533 approaches to be diverse, thus hindering in-depth overall conclusions. Nevertheless, the
534 comparison of paper findings indicated that farmers' personality and attitudes impact on dairy
535 cattle health, welfare, productivity and management. In general, attitudes indicating higher
536 degrees of knowledge, affection with problems, perceived responsibility, perception of control
537 of a situation, a more positive human-animal relationship and positive evaluation of the benefits
538 of management decisions tended to impact in a beneficial way on outcomes. While attitudes
539 were related to all thematic (outcome) areas, and personality measures were only reported to
540 impact on management aspects and dairy productivity, over-interpretation regarding a possible
541 predominance of their effect on specific dairy production areas must not be done.

542 *The review approach*

543 To date, as a consequence of expanding evidence based practice across all sectors, there is an
544 increasing variety of review approaches (Grant et al., 2009). Scoping reviews, on the one hand,
545 aim to identify nature and extent of research evidence by preliminary assessing potential size
546 and scope of research literature. They characterize quantity and quality of literature by study
547 design and other key features. On the other hand, systematic reviews focus on appraisal and
548 synthesis of research evidence. These often adhere to guidelines on the conduct of a review and
549 address uncertainty around findings, what remains unknown and develop recommendations for
550 future research (Grant et al., 2009). Due to our objectives, we chose a mixed-method approach
551 combining core aspects of systematic and scoping reviews as a tool for our investigations as we
552 considered a mere quantification and quality assessment of literature as too superficial for the
553 topic investigated. Per Grant et al. (2009), meta-analysis is listed as an own category in the
554 context of reviews. It is supposed to statistically combine the results of studies aiming to a more
555 precise effect of results. Meta-analytic results are based on numerical analysis of effects
556 assuming absence of heterogeneity between reviewed papers. However, our results showed the
557 reviewed papers not to be appropriate for such synthesis at the current stage.

558 *Search strategy*

559 The few references gathered from the reference lists of relevant publications indicated an
560 efficient search strategy. By restricting publications to German and English, we may have
561 missed publications. Grey literature and website searches were omitted. This would have been
562 crucial for conduct of a meta-analysis, in which an overall effect is calculated based on the
563 individual outcome of the identified articles (McAuley et al., 2000). However, due to the
564 diversity of approaches, variables and outcomes in the reviewed papers, a meta-analysis was
565 not feasible. Instead, our review only included peer-reviewed publications that were deemed
566 appropriate by experts in the same field (Kelly et al., 2014) to describe the impact of attitude
567 and personality as risk factors for dairy cattle health, welfare, productivity and farm
568 management. Many publications were dismissed during paper selection as they considered
569 attitude and personality as outcomes, reported only descriptive results, dealt with outcomes or
570 species not meeting eligibility criteria or focused on the effectiveness of intervention on
571 attitudes. These articles may have an important impact regarding their research field; however,
572 they did not yield information we needed (i.e. results and discussion about the impact of attitude
573 and personality as risk factors for dairy cattle health welfare, productivity and farm
574 management).

575 We used well-known and evaluated methods and techniques to identify relevant literature and
576 exclude irrelevant papers (e.g., Papaioannou et al., 2010). Nevertheless, the search strategy
577 includes certain researcher specific decisions, for example on which concepts and keywords to
578 include or not to include. To substantiate our decisions we discussed them with colleagues from
579 the dairy herd health unit and librarians of our university. Nevertheless, it cannot be ignored
580 that other researchers would have decided for slightly different keywords. Hence, this might
581 have resulted in a slightly different list of papers. Therefore, we reported on the search strategy
582 and our findings can only be related to this.

583 *Spectrum of studies on personality and attitude as risk factors*

584 Research on personality and attitude as risk factors for dairy health, welfare, productivity and
585 management has involved researchers in many countries worldwide. We found that personality
586 and attitude were investigated relative to their influence on management and dairy cattle health
587 more frequently than on welfare and productivity (see Table 6 for attitude assessment). This
588 might be because farmers' management decisions can be considered the basis for any activity
589 implemented on farms and animal health is a basic requirement for achieving animal welfare
590 and productivity. Another reason could be that management decisions and animal health
591 parameters are easier to measure than welfare indicators and productivity, which require
592 complex on-farm observations or analyzing secondary data such as production records.

593 *Theoretical background and item disclosure.* Transparency is an important feature of
594 scientific research. Miguel et al. (2014) stressed the importance of open data and materials,
595 especially in social science research. Open data and materials “provide the means for
596 independent researchers to: reproduce reported results; test alternative specifications on the
597 data; identify misreported or fraudulent results; reuse or adapt materials (e.g., survey
598 instruments) for replication or extension of prior research and; better understand the
599 interventions, measures and context – all of which are important for external validity” (Miguel
600 et al., 2014). We concentrated on whether two main aspects that we deemed important in the
601 context of our review were presented lucidly. These were (1) explanation of theoretical
602 backgrounds (incl. psychological objects) for risk factor assessment and (2) disclosure of
603 questionnaire items or interview questions used.

604

605 As theoretical backgrounds and items used to assess risk factors were not comprehensively
606 reported in all records, future reporting might benefit from inclusion of more detailed
607 information to enhance reproducibility and evaluation by independent researchers. Reporting
608 the theoretical background, for example, increases the comprehensibility of study hypotheses.

609 TPB or TRA, which have been mentioned as theoretical backgrounds for assessing attitude,
610 link factors that impact a person developing certain behavioral intentions. The person's attitude
611 is one of these factors, which may therefore help to predict behavior (Ajzen, 2001). These
612 theories are especially applicable when the dependent variable is a behavioral intention or an
613 observed behavior (Fig. 3a). We investigated farm management as a thematic (outcome) area,
614 and these theories can be directly applied to the impact of attitudes on farmers' behaviors or
615 management decisions. However, most studies summarized in this review focused on outcome
616 variables other than behavior or behavioral intentions (e.g., milk yield, prevalence of disease).
617 Therefore, the analyzed risk factor and the outcome appeared to be indirectly related (Fig. 3b).
618 For example, when assessing the relationship between an attitude such as "empathy with the
619 dairy cows" and milk yield (Hanna et al., 2009; Fukasawa 2017), the hypothesis might be that
620 a certain attitude influences the farmer towards a certain management decision, which itself
621 increases or decreases the herd's milk yield. However, here the psychological object differs
622 from the farmer's behavior, and the farmer's behavior itself is not assessed. Hence, this
623 approach differs from the classical assessment of how attitude impacts behavior and this
624 example illustrates why researchers should report the causal theory behind their hypotheses.
625 When interpreting relationships between attitude and animal-related outcomes it should be
626 considered to which psychological objects an attitude was assessed and which farmer's
627 behavior is suggested to impact animal-related outcomes. As one result of this review was that
628 the associations between attitudes, psychological objects and outcome were not always
629 described in an easily comprehensible manner, visualization of the hypothesized associations
630 may help to improve understanding (i.e. by use of causal diagrams; Dohoo, 2009). Here, all
631 factors involved in the causal situation can be included, even those not analyzed.

632

633 Disclosing the items used to collect data is also important for ensuring clarity, particularly as
634 no fixed item sets exist for assessing attitude, in contrast to personality. According to Schwarz

635 (2001), a question's answer or a statement's rating can be influenced by small changes in an
636 item's wording or an answer scale's design. As attitudes towards identical psychological objects
637 can be assessed using different items, we encourage reporting questionnaire items to facilitate
638 comparing and interpreting results.

639 **Data collection.** In the studies included here, **personality** was assessed most often by
640 those personality domains included in the Five-Factor model. However, the nomenclature in
641 these domains was inconsistent between the articles (Table 4). This might be because the
642 nomenclature differs even in the socio-psychologic literature. Therefore, it may be beneficial
643 to develop harmonized nomenclature, at least within specific research fields (i.e., dairy science).
644 Of course, the issue of nomenclature is not only apparent in this field of research. For example,
645 different nomenclature and scoring systems exist for the assessment of lameness conditions in
646 cattle (Penev, 2011).

647 Well-established and broadly accepted personality assessment theories exist, such as the Big-
648 Five or HEXACO. Item sets to assess personality domains are freely available and have been
649 scientifically validated in different languages (Goldberg et al., 2006). These item sets contain
650 different numbers of statements including validated short versions, which allow their use even
651 when time or space is limited (Gosling et al., 2003; Ashton and Lee, 2009; de Vries, 2013);
652 therefore, we believe that using unconventional, non-validated inventories should be avoided
653 where possible, and if they are used this should be well-founded and explained.

654 In contrast to personality measures that are limited to a set number of theoretical domains and
655 facets, no such limitation exists for **attitudes**. The variety of attitudes that can be investigated
656 is as large as the number of psychological objects imaginable. The researcher must consider
657 which and how many psychological objects (objects towards which attitude is assessed) are of
658 interest regarding their possible influence on the dependent variables (farm-specific outcomes
659 concerning animal health, welfare, productivity and management). Again, this highlights why

660 it so important to explain the theoretical background (e.g. by drawing a causal diagram; see
661 discussion above). Furthermore, as can be seen from table 5, where we proposed generic terms
662 and topics to subsume psychological objects, harmonization of terms and definitions regarding
663 certain well-investigated psychological objects would, in general, be possible and could
664 increase future overall discussion of study findings.

665

666 *Information extraction and data processing.* We focused on questioning the methods
667 that the researchers chose. We did not evaluate whether the reported approaches were suitable
668 for the data to which they were applied.

669 The common method for extracting **personality** data condenses several questionnaire items
670 into a smaller number of personality dimensions. Using a validated inventory or item pool
671 related to the Big-Five or HEXACO clearly defines which items code for which personality
672 dimension. However, this is not the case when self-tailored question sets are used to assess
673 personality. In these cases, clear descriptions of the data extraction method are needed to ensure
674 comprehensibility and reproducibility (Miguel et al., 2014).

675 When assessing **attitudes**, the researcher must decide how to condense items. Principle
676 component analysis was used most frequently for that purpose in the studies in this review. The
677 nomenclature of the resulting attitude classes remains the researcher's decision. Using the same
678 questionnaire items and operating partial correlation analysis for extraction, Hanna et al. (2009)
679 extracted four attitude classes related to the psychological object "working with dairy cows"
680 out of 42 questionnaire items ("empathy", "negative beliefs", "job satisfaction" and "patience"),
681 while Fukasawa et al. (2017) extracted only three attitude classes and labeled one differently
682 ("positive beliefs", "negative beliefs", "job satisfaction"). Hence, variation in procedures used
683 to condense and deduce latent information may impair reproducibility. However, the fact that
684 identical questionnaire items lead to different attitude classes supports our impression that

685 attitude assessment results cannot be compared at the most detailed level, at least not under the
686 given conditions without standardization of generic terms for psychological objects and a
687 precise description of the anticipated association between attitude, psychological object and
688 outcome.

689 ***Risk factor analysis.*** Correlation and regression analyses were the methods used most
690 frequently to analyze and interpret relations between farmers' personalities and outcomes. The
691 process of classifying and interpreting the results differed in the parameters chosen to derive
692 their significance and relevance. This heterogeneity is an obstacle to comparing the results and
693 should be considered when interpreting them.

694 ***Relationship between personality and attitude and dairy cattle health, welfare, productivity***
695 ***and management***

696 As 50% of the reviewed papers found personality influences, and 94% found attitude
697 influences, we conclude that personality and attitude are likely to impact on aspects of dairy
698 cattle health, welfare, productivity and farm management. However, we caution against over-
699 interpretation of the finding that attitudes were related to all thematic (outcome) areas, while
700 personality measures were only reported to impact management aspects and dairy productivity.
701 One reason for this observation may be that the researchers' interests influenced their study
702 hypotheses, and this should not be misinterpreted to imply that personality does not impact
703 dairy health or welfare.

704 When considering whether an overall conclusion can be drawn regarding the impact of attitude
705 and personality on dairy cattle health, welfare, productivity and management, we believe that
706 the complexity and heterogeneity must be considered, especially regarding attitude. Whereas,
707 a standardized and evaluated model and validated questionnaires exist for personality, there are
708 diverse approaches to processing data, analyzing risk factors and interpreting results. This can
709 hinder comparison of studies even on identical attitudes.

710 Publication bias should be considered, as researchers who revealed no relationships between
711 risk factors and outcome variables may be less likely to have published their results (Ioannidis,
712 2005), or scientific journals may have preferentially published detected effects and significant
713 results (Dohoo, 2009). Furthermore, the thematic outcome variable areas we investigated here
714 may have been of differing interest for scientists, professionals or politicians in past years;
715 therefore, they may have been excluded in scientific research to some degree. This may also
716 have biased the information we could gather at this point. Finally, assuming that all
717 observational studies considered in this review require voluntary participation it is also
718 necessary to consider selection bias. Therefore, results of the published papers may not be
719 universally valid for the source population but restricted to the study group (Dohoo, 2009).

720 The heterogeneity of the psychological objects assessed and the variable methods applied to
721 collect, analyze and interpret data in attitude assessment impede development of a general
722 overall conclusion of how attitudes impact dairy cattle health, welfare, productivity and
723 management. However, the answer to the question of which attitude affects which outcomes
724 depends on the details of the view. As we show farmers' attitude towards "working with dairy
725 cows" impacts on dairy cattle health, welfare, productivity and management. However, each
726 study extracted different information from different questionnaire items and extracted this
727 information differently. Thus, diversity increases with the depth of detail. This issue, though, is
728 not only apparent in attitude assessment. We discover this phenomenon also in other fields of
729 veterinary science. For example the recording of infection diagnostics may span from
730 qualitative (yes/no in culture) over quantitative (OD% in ELISA) records towards molecular
731 typing in order to describe the detection of pathogens. This could result in similar problems
732 comparing findings due to different levels of detail. Hence, we have to expand our attention
733 regarding this problem from the risk factors to the outcome variables, as well. When comparing
734 information from different levels of detail the most straightforward solution is to pull together
735 information on the highest hierarchical level apparent (e.g. diagnostic test positive vs. negative).

736 Although this may result in a loss of interpretative depth, it enables suggestion of an overall
737 conclusion. Within the review presented here this kind of higher level advance to compare study
738 findings was applied especially on papers investigating farmers' attitudes as those showed the
739 greatest amount of heterogeneity. As shown in table 5, it was possible to aggregate different
740 psychological objects into topics. For that purpose it was necessary to consider the contextual
741 meaning behind the detailed label of the psychological objects. In this case, the advance on a
742 higher level of detail made it possible to come to overall conclusions. This points out the
743 benefits of our detailed, framework-centered approach to this review: focusing on details of
744 theoretical frameworks is necessary to understand and use the concepts properly; however,
745 putting results in relation to practical use (i.e. what do we learn by summing up different
746 research results) requires a wider view of results. Nevertheless, it has to be taken into
747 consideration that comparing results of different papers on a higher level of detail might also
748 lead to false overall conclusions.

749 Considering these methodological challenges this scoping review enabled some general overall
750 conclusions regarding personality and attitude as possible risk factors for dairy cattle health,
751 welfare, productivity and management.

752 **Health.** It is comprehensible that job satisfaction (i.e. evaluating the task of milking as positive)
753 positively impacts on cell counts (Tarabla & Dodd, 1990), as milking is a task that is
754 characterized by a high degree of routine and maybe even monotony. Therefore, high regard of
755 the task may lead to more conscientious work and might positively affect hygiene and
756 inspection of animals, which are important to prevent mastitis and recognize udder infection at
757 an early stage. Another attitudinal aspect which has been shown to impact on the animals' health
758 is the farmers' evaluation of the managerial on-farm situation. Being aware of shortcomings
759 (Schewe et al., 2015), and knowing about important parts of farm management (Silverlas et al.,
760 2013) is important to make proper management decisions. The findings of Schewe et al. (2015),

761 who reported that farmers seeing both, mastitis and not following protocols properly, as a
762 problem was associated with higher cell counts, has to be interpreted carefully as regards the
763 direction of the association. Normally, one would expect such awareness to be a good basis for
764 a change within management to tackle the problem. However, farmers' perceptions could also
765 result in self-fulfilling prophecies; or the awareness of the shortcomings may only be a result
766 of high cell counts. Other factors reported to impact on animal health have to do with the
767 empathic setting of the farmer. Thinking that animals feel pain as humans do (Kielland et al.,
768 2010) indicates a high degree of emotional attachment to the animals and might result in better
769 care. However, it was also observed that when a stillbirth from a heifer was regarded as less
770 severe than a stillbirth from a cow, the farm health status might be affected negatively
771 (Santman-Berends et al., 2014). Here, it becomes clear that farmers also have to consider
772 economic factors, which may be evaluated superior to emotional attachment with animals by
773 some stockpeople. Finally, the fact that farmers with higher odds of being a bTB case felt more
774 often that other people or institutions could not help them with their problems, stresses the fact
775 that proper information and support-strategies are crucial and this topic should be addressed by
776 professionals and politicians.

777 **Welfare.** Results show that the concept of human-animal relationship is in the center of the
778 investigation of attitudes' impact on animal welfare. Aversive cow behavior (flinches, steps,
779 kicks in the milking parlor; Breuer et al., 2000) and avoidance distance within approach tests
780 (De Roches et al., 2016) were shown to be influenced by farmers' attitudes towards the animals.
781 Favorable attitudes resulted in better welfare. These results are in compliance with other
782 research investigating human impact on stress in farmed animals (e.g. Hemsworth et al., 1989;
783 Jones, 1993). It has to be noted that both, Breuer et al (2000) and De Roches et al. (2016), assess
784 the impact of attitudes on welfare as part of a hypothesized causal chain finally aiming on
785 assessments of effects on productivity. Therefore, these studies may be seen as good examples
786 for proper construction of hypotheses and good reporting of theoretical backgrounds.

787 **Productivity.** It is easily comprehensible that emotionally labile farmers (i.e. neurotic persons;
788 Arias and Spinka, 2005) may affect the productivity of cows. This finding substantiates
789 Seabrook et al. (1972) who found certain traits (e.g. motives, emotion) to lead to decreased milk
790 yield. Anxious, angry or depressed persons may act accordingly when handling their animals.
791 Stressed cows may then show a decreased milk yield as the negative effect of stress on the
792 productivity of farmed animals has also been shown for various other species (Hemsworth et
793 al. 1981; Barnett et al., 1992; Cransberg et al. 2000; Hemsworth et al.; 2000). On the other hand
794 Hanna et al. (2009) could not find a personal characteristic like impatience to lead to decreased
795 milk yield. Therefore, it seems of critical importance not to over-interpret all improper behavior
796 of stockpersons as compulsory risk factors for milk yield. Animals can get used to different
797 kinds of persons and the level of stress might decrease as the animals have adopted to a certain
798 kind of handling for example (Grandin, 1997). Hence, it could be of special interest to think
799 about which other consequences might occur within the daily farm business, if the farmer scores
800 high for the above mentioned personality facets. Anger and depression might curb mental and
801 emotional resources, which again may lead to a decreased ability of stockpersons to keep an
802 overview on the needs of the animals and necessary tasks. It has been shown that feeling in
803 control of a situation impacts positively on performance (Vaarst & Sorensen, 2008; Jansen et
804 al., 2009). On the other hand, a lack of feeling in control can curb ones' ability to act upon the
805 real situation (Ajzen, 1991). In this context, being depressed could also result in the feeling of
806 losing control. This hypothesis corresponds with the findings that attitude can impact on milk
807 yield, as well (Hanna et al., 2009: "empathy"; Breuer et al., 1999 and Seabrook, 1972: "job
808 satisfaction"). Being satisfied with ones' job (i.e. working with dairy cows and being a farmer)
809 and holding positive beliefs about cows (Fukasawa et al., 2017) is a prerequisite for an open-
810 minded relationship with the animals, appropriate handling of cows (Hemsworth et al., 2000),
811 openness to technical further education (i.e. gain of knowledge) and awareness of shortcomings

812 or upcoming difficulties. The consequence can be proper management decisions. This might
813 lead to less stressed and healthier cows and a higher milk yield.

814 **Management.** It is understandable that attitudes representing higher degrees of technical
815 knowledge (Toma et al., 2015; Ritter et al., 2015) were shown to favorably mediate
816 management decisions. Therefore, communication of knowledge (e.g. about characteristics of
817 pathogens or aims of interventions) should be seen as an important aspect by professionals
818 when providing farmers with advice. This is in compliance with the findings of Bruijnis et al.
819 (2017) and Vande Velde et al. (2015) who revealed that farmers have to be convinced about the
820 usefulness of management decisions to increase the odds of implementation. Beside these
821 aspects farmers' management, decisions were shown to depend on economic considerations as
822 well. Making management decisions, farmers evaluate cost effectiveness (Scherpenzeel et al.,
823 2016; Jones et al., 2015; Martinez-Garcia, 2013), ease of management (Martinez-Garcia, 2013)
824 and time constraints (Ritter et al., 2015). These findings highlight that farmers might see
825 themselves in an area of conflict. This conflict is expressed in the wish to make the best decision
826 for their farm and feeling responsible (Toma et al., 2015), on the one hand, and financial
827 pressure and high workloads, on the other hand; this may be very pertinent as both financial
828 pressure and workload have increased in the dairy sector within the past decades (do you have
829 a reference for this). This conflict should also be kept in mind when evaluating effects related
830 to job satisfaction and the issue of stress in daily farm business.

831 ***Overall Conclusion***

832 We provide an overview of research on the impact of farmers' personalities and attitudes on
833 dairy cattle health, welfare, productivity and farm management, focusing on the spectrum of
834 studies as well as on the relationships between personality and attitude and the dependent
835 variables.

836 Research, conducted in several countries, suggests that farmers' personalities and attitudes
837 influence dairy cattle health, welfare, productivity and farm management. This effect was
838 shown by more studies for attitude than for personality.

839 We believe that comparing manuscripts at a detailed level regarding the impact of certain
840 attitudes and personality dimensions is impeded due to variable methods of collecting,
841 analyzing and interpreting data, the heterogeneity of psychological objects assessed and the
842 many dependent variables per thematic area investigated. Furthermore, reporting the theoretical
843 backgrounds and disclosing (question) items should be improved. We therefore encourage full
844 disclosure of materials, as well as consideration of ways to harmonize assessing attitudes and
845 personality measures, to promote comparison and enhance interpretation of results.

846 However, comparison of papers on a less detailed level revealed that personality dimensions
847 and attitudes indicating favorable traits and opinions are associated with better dairy cattle
848 health, welfare, productivity and farm management. Therefore, further research on these
849 farmer-intrinsic aspects and their consideration by professionals and decision-makers within
850 the dairy sector and politics is strongly recommended. This might provide the chance to better
851 understand the needs of dairy farmers and therefore develop tailored advice and support-
852 strategies to improve both satisfactory and constructive cooperation.

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1071

TABLES

1072

1073 Table 1. Concepts and keywords operated in the final database search in English

Concept 1	Concept 2	Concept 3	Concept 4	Concept 5
farmer*	personalit*	welfare	dairy	relation*
stockperson*	„personal characteristics“	wellbeing	cow*	associat*
stockman*	attitude*	productivity	cattle	correlation*
herdsman / herdsmen		health*	calve*	influence*
producer*		management	heifer*	effect*
rancher*		performance		
smallholder*				

1074 Columns are linked with Boolean AND-operators. Lines are linked with Boolean OR-operators.

1075 * indicates wildcard operator allowing any number of additional letters.

1076 Words in quotation marks are regarded as connected terms.

1077

1078 Table 2. Concepts and keywords operated in the final database search in German

Concept 1	Concept 2	Concept 3	Concept 4	Concept 5
Landwirt*	Persönlichkeit*	Wohlergehen	*kuh*	Einfluss
Nutztierhalter	Einstellung*	Tierwohl	*kühe	Einflüsse
		Produktivität	Milchvieh*	Korrelation*
		Management	*rind*	Verhältnis
			Kalb	Beziehung*
			Kälber*	Zusammenh*
			Färse*	Assoz*

1079 Columns are linked with Boolean AND-operators.

1080 Lines are linked with Boolean OR-operators.

1081 * indicates wildcard operator allowing any number of additional letters.

1082 Words in quotation marks are regarded as connected terms.

1083

1084 Table 3. Numbers (n) of records per country (38 records included)

Country of research	Records (n)
United Kingdom	11
Netherlands	5
Norway	3
Australia	2
Austria	2
USA	3
Sweden	2
Finland	2
Denmark	2
Czech Republic	1
France	1
Canada	1
India	1
Ethiopia	1
Japan	1
New Zealand	1
Uruguay	1
Belgium	1
Mexico	1
Total	43*

1085 *= one study included data from Norway, Sweden, Finland and Denmark. Another includes data from New Zealand and Uruguay.

1086

1087 Table 4. Personality domains assessed as named by the authors (four records included)

Personality domain	Records assessing this domain (n)
Extraversion	3
Agreeableness	3
Conscientiousness	3
Neuroticism	2
Emotional stability	1
Intellect	1
Agreeable	1
Confident extravert	1
Pessimistic	1
Openness to experience	1
Openness	1

1088 Table 5. Psychological objects and topics considered for attitude assessment (37 records included)¹

Attitude Topic	Psychological Object ²	Number of records ³ (n)
Dairy Cows	Statement: "Animals feel physical pain as humans do"	2
	Working with dairy cows	6
	Dairy cows	4
	Characteristics of dairy cows	4
	Interacting with dairy cows	1
	Productivity of local breeds	1
	Cattle (heifers)	1
Drug Use	Mastitis related antimicrobial agent use	2
	Anthelmintic drugs	1
	Reduction of antibiotic usage in the animal industry	1
	Dry cow therapy	1
	Use of antibiotics	1
Other Infectious Diseases	Bovine tuberculosis	1
	Johne's disease	1
	Alberta Johne's disease Initiative	1
	Nematode diagnostic methods	1
Mastitis/Udder Health	Mastitis	4
	Udder health	1
	Mastitis management	1
	Contacting a vet the same day when detecting mild clinical mastitis in a lactating cow	1
Calves	Calf mortality	2
	Calf rearing	1
	Calf disease	1
Biosecurity	Adoption of control measures for E. coli	1
	Biosecurity	3
Work Routines	Taking action to improve cow foot health	1
	Milking	1

	Using improved grassland	1
	Dairy production technologies	1
	Use of MDC recommended observation times for oestrus detection	2
	Use of podometers for oestrus detection	1
	Use of milk progesterone test kits for oestrus detection	1
Animal Welfare	Animal welfare	1
	Improving animal welfare	1
stockpersons' job	Stockperson's job	2

1089

1090

1091

¹= as some papers investigated attitudes towards more than one psychological object, these papers are displayed more than once²=Wording was taken over as presented in the records without any interpretation concerning textual meanings³=Number of records assessing attitude towards that psychological object

1092

1093 Table 6. Relationships between attitudes (towards different psychological objects) and dependent variables (sorted by thematic areas)

Psychological object considered “Attitude towards...”																																			Paper’s citation*	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35		
Animal productivity																																				
	X																																			(Hanna et al., 2009)
X												0																								(Fukasawa et al., 2017)
	X			X																																(Breuer et al., 2000)
X									X																											(Waiblinger et al., 2002)
							0																													(Kielland et al., 2010)
0																																				(Arias and Spinka, 2005)
																							X													(Tarabla and Dodd, 1990)
																															0					(Bertenshaw and Rowlinson, 2009)
																										0										(Kauppinen et al., 2013)
													X																							(Seabrook, 1972)
Farm management																																				
											0																									(Bruijnis et al., 2013)
	X			X																																(Breuer et al., 2000)
0									X																											(Waiblinger et al., 2002)
	X			X																																(Hemsworth et al., 2000)
														X																						(Alemayehu et al., 2010)
				0																																(Heffernan et al., 2008)
	X			X																																(Kayitsinga et al., 2017)
															X	X																				(Ritter et al., 2015)

Psychological object considered “Attitude towards...”																																			Paper’s citation*		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35			
									X									X																		(Scherpenzeel et al., 2016)	
																			X																	(Toma et al., 2015)	
			X																X																	(Toma et al., 2013)	
																				X	X															(Vande Velde et al., 2015)	
																							X													(Espetvedt et al., 2013)	
																								X												(Martinez-Garcia et al., 2013)	
																													X							(Jones et al., 2015)	
																												X								(Rao et al., 1990)	
																															X					Rehman et al., (2007)	
																														X		X	X			Garforth et al., (2006)	
Animal welfare																																					
	X			X																																(Breuer et al., 2000)	
X	X																																			(Roches et al., 2016)	
																																		0		(Bertenshaw and Rowlinson, 2009)	
																											X										(Kauppinen et al., 2013)
Animal health																																					
																																		X		(Borne et al., 2014)	
																																			0	(Vaarst and Sorensen, 2009)	
			X			X																															(Schewe et al., 2015)
			X																																		(Jansen et al., 2009)
																																					(Kielland et al., 2009)

Psychological object considered “Attitude towards...”																																			Paper’s citation*	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35		
0																																				(Arias and Spinka, 2005)
													X																							(Broughan et al., 2016)
	X			X																																(Rouha-Mulleder et al., 2009)
																							X													(Tarabla and Dodd, 1990)
							X										X																			(Santman-Berends et al., 2014)
			X																																	(Silverlas and Blanco-Penedo, 2013)
								X																												(Kjelland et al., 2010)
	X																																			(DeLong et al., 2017)

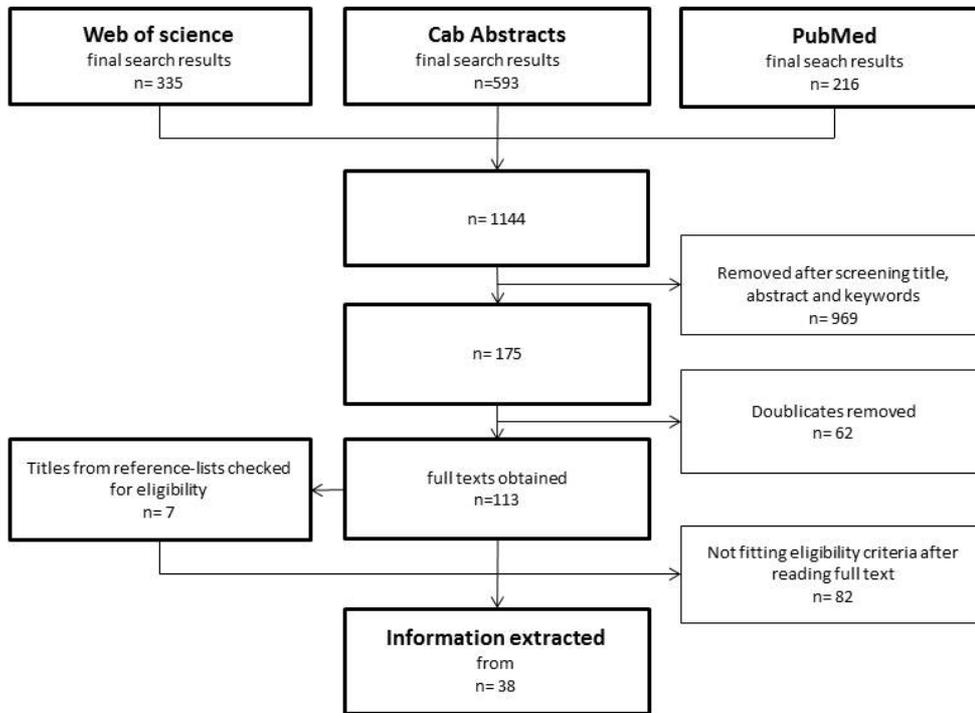
1094 1=Dairy cows; 2=Working with dairy cows; 3= Mastitis; 4= Biosecurity; 5= Characteristics of dairy cows; 6= Mastitis related antimicrobial agent use; 7= Calf mortality; 8= Statement: “Animals feel physical pain as humans
 1095 do”; 9= Interacting with dairy cows; 10= Reduction of antibiotic usage in the animal industry; 11= Taking action to improve cow foot health; 12= Udder health; 13= Stockperson’s job; 14= Bovine tuberculosis; 15= Productivity
 1096 of local breeds; 16= Johnes’ disease; 17= Alberta Johnes’ disease Initiative; 18= Calf rearing; 19= Dry cow therapy; 20= Adoption of control measures for *E. coli*; 21= Animal welfare; 22= Anthelmintic drugs; 23= Nematode
 1097 diagnostic methods; 24= Milking; 25= Contacting a vet the same day when detecting mild clinical mastitis in a lactating cow; 26= Using improved grassland; 27= Improving animal welfare; 28= Dairy production technologies;
 1098 29= Calf disease; 30= Use of antibiotics; 31= Cattle (heifers); 32= using MDC recommended observation times for oestrus detection; 33= mastitis management; 34= using milk progesterone tests kits for oestrus detection;
 1099 35=using podometers for oestrus detection
 1100 X= relation reported between attitude and dependent variable
 1101 0= no relation reported between and dependent variable
 1102 *As some papers investigate dependent variables from more than one thematic area these papers are displayed more than once.
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1105

FIGURES

1106 (Adler) Figure 1. Number of records captured in final database searches and removed at different stages of the
 1107 paper selection process

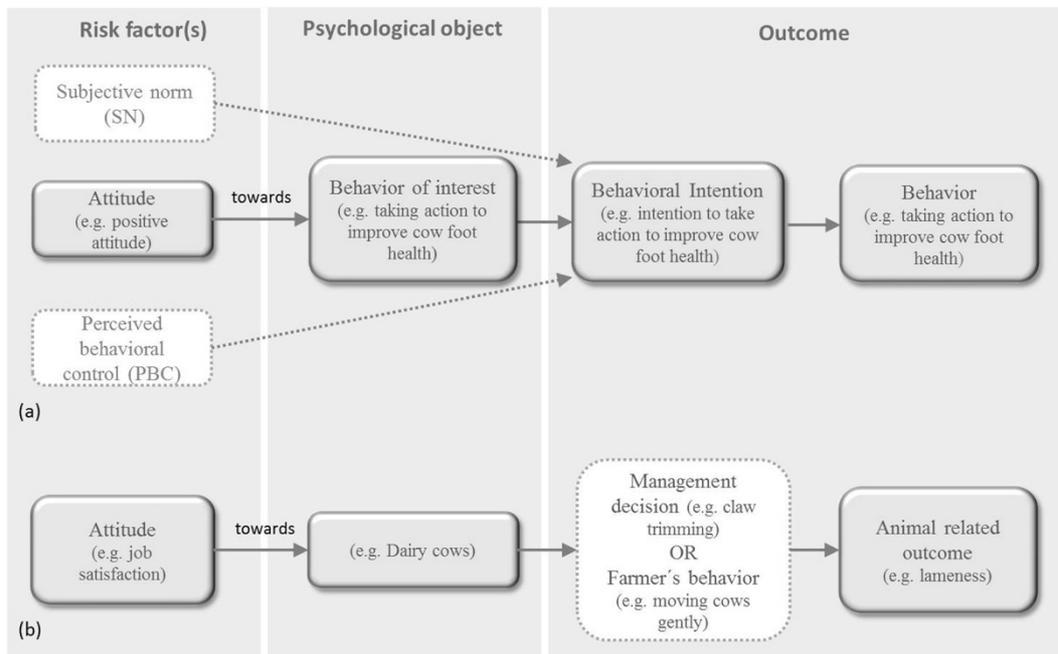


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1111 (Adler) Figure 2. Causal Diagram to assess the impact of attitudes on an outcome; (a) Causal relation between
 1112 farmers’ attitude and farmers’ behavior, (b) Causal relation between farmers’ attitude and animal related
 1113 outcome



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