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1 **Automatic milking systems in dairy cows' operations: A scoping review protocol**

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22 **Abstract**

23 *Background:* Automatic milking systems (AMS) are trending upwards in the USA and
24 future reductions in availability of milking labor and potential increase in labor costs are
25 influencing the increase in AMS adoption. In addition, more interest in precision dairy
26 farming by the new generation of farmers may also play a role increasing AMS adoption.
27 A formal scoping review of the literature relevant to AMS in dairy cows' operations
28 would help to identify areas for evidence synthesis and gaps in the literature to target
29 future research.

30 *Objectives:* This protocol describes the methods for a scoping review to address the
31 question "What is the nature and volume of the primary research literature on AMS in
32 dairy cows' operations?".

33 *Eligibility criteria:* Primary research studies published in English since 2000 that
34 investigate various outcomes related to the adoption of automatic milking systems in
35 dairy cows' operations.

36 *Sources of evidence:* The electronic databases that will be searched are the following:
37 Biosis (Web of Science), CAB Abstracts (CAB Direct), Medline (PubMed), and Scopus
38 (Scopus). Grey literature will be searched using S-PAC.

39 *Charting methods:* Data charting will include study objective, study characteristics, farm
40 and AMS information.

41 **Introduction**

42 *1.1. Rationale*

43 Automatic milking systems (AMS) are trending upwards in the USA and,
44 although technologies such as box robots have been in use for more than 27 years in
45 Europe, the adoption rates have been slower in the USA. Some of the reasons may include

46 higher proportion of large farms than countries that have more rapidly adopted AMS
47 technology and producer uncertainty about adopting the new technology (Jacobs and
48 Siegford et al., 2012). One of the primary obstacles to implementing AMS is the higher
49 capital cost of the milking equipment and facilities compared to conventional milking
50 technology. However, trends to future reductions in availability of milking labor and
51 potential increase in labor costs are influencing the increase in AMS adoption, as well as
52 more interest in precision dairy farming.

53 To date, there has not been a published scoping review summarizing the literature
54 related to automatic milking systems in dairy cows' operations. A scoping review on this
55 topic could be useful for identifying specific topics with enough depth of literature to
56 support a systematic review and to identify research gaps.

57 *1.2.Objectives*

58 The objective of this protocol is to describe the methods that will be used to conduct
59 a scoping review to address the following research question: "What is the nature and
60 volume of the primary research literature on automatic milking systems in dairy cows'
61 operations?". The scoping review will follow the methodological framework outlined by
62 Arksey and O'Malley (1995).

63 **2. Methods**

64 *2.1.Protocol and registration*

65 This protocol was prepared using the Preferred Reporting Items for Systematic
66 reviews and Meta-analysis Extension for Scoping Reviews (PRISMA – ScR)
67 reporting guidelines (Tricco et al., 2018) and will be published on scholarship from
68 University of California. The protocol will also be available at SYREAF
69 (www.syreaf.org). Protocol was updated in eScholarship 31 May 2023 to reflect

70 updated search and inclusion criteria update prior to screening excluding grazing
71 cattle.

72

73 *2.2. Eligibility criteria*

74 *To be eligible for inclusion in this review, studies must be:*

- 75 1) Available in English, including studies published in English from any country.
- 76 2) Available in full text of at least 500 words, to allow enough detail for data
77 characterization.
- 78 3) Not exclusively focused on grazing?
- 79 4) Publish during or after 2000.
- 80 5) A primary research design, including descriptive study designs, experimental
81 designs, and analytical observational designs. At full-text screening, the number
82 of studies conducted as systematic reviews and metaanalyses will be quantified,
83 but these studies will not be further characterized.

84 *2.3. Information sources*

85 Four electronic databases will be search for eligible studies from January 1, 2000
86 to the date of the search: Biosis (Web of Science), CAB Abstracts (CAB Direct),
87 Medline (PubMed), and Scopus (Scopus). Grey literature will be included by
88 searching S-PAC. The citations resulting from the database searches will be uploaded
89 into Zotero® and de-duplicated using internal algorithms. Bridge or updated search
90 was deduplicated using Sciwheel (Sage Publications). De-duplicated citations then
91 will be imported into Covidence® review management software, where additional de-
92 duplication will be conducted prior to eligibility screening. Following full-text
93 screening, an additional manual de-duplication will be conducted.

94 2.4. Search

95 PRISMA-S Template (based on v1.0 retrieved from <https://osf.io/2ybwn/>)

96

97 **(Literature and information being sought)**

98 Automated Milking Systems for Cattle

99 **Databases and Interfaces Searched:**

100

Database	Interface	Date Coverage	Date Searched
CAB Abstracts <small>(included products: CAB ABSTRACTS, VetMed Resource, CABI Full Text, Global Health, Animal Health and Production Compendium (AHPC))</small>	Cab Direct	1973 to Present	22.12.2020 Bridge Search 17 August 2022
Medline <small>(included products: Medline, in process citations, "ahead of print" citations, out-of-scope citations, journals indexing prior to medline inclusion, pre-1966 citations, PubMed Central, author manuscripts NIH funding, NCBI Bookshelf)</small>	PubMed	1946- Present	22 December 2020 Bridge Search 17 August 2022
Scopus	Scopus	1823- Present	22 December 2020 Bridge Search 17 August 2022
Biosis	WEb of Science	1926- Present	22 December 2020 Bridge Search 17 August 2022
PubAg	PubAg	1997- Present	22 December 2020 Bridge Search 17 August 2022
AGRIS	FAO	1975- Present	22 December 2020 17 August 2022

101

102 **Simultaneous Searches:**

103 **None performed**

104

105 **Item 2: Other Online Resources (As Needed):**

106

Conference Proceeding/Registry/ Web Sites or Engine	Coverage Dates	Membership Required?	URL	Date Searched:
S-PAC (Searchable Proceedings of Animal Conferences)	1935-Current	Yes (Institutional)	https://spac.adsa.org/index.asp	19 November 2020

107

108 **Manual Searching (searching relevant journals Table of Contents):**

109

Journal Title	Print or Online?	Coverage Dates
Dairy Science	Online	2000-2020

110

111 **Citation Searching And Text Analysis:**

112

Article Citation:
Castro A, Pereira JM, Amiama C, Bueno J. Estimating efficiency in automatic milking systems. J Dairy Sci. 2012 Feb;95(2):929-36. doi: 10.3168/jds.2010-3912. PMID: 22281358
Hermans GG, Ipema AH, Stefanowska J, Metz JH. The effect of two traffic situations on the behavior and performance of cows in an automatic milking system. J Dairy Sci. 2003 Jun;86(6):1997-2004. doi: 10.3168/jds.S0022-0302(03)73788-6. PMID: 12836935.
Brzozowski M, Piwczyński D, Sitkowska B, Kolenda M. The impact of installation of automatic milking system on production and reproduction traits of dairy cows. Reprod Domest Anim. 2018 Oct;53(5):1123-1129. doi: 10.1111/rda.13214. Epub 2018 Jun 25. PMID: 29943502.

113

114 **Process:** Key articles were identified by Principal Investigator and keywords were
115 mined by finding references in PubMed and CAB Direct. Keywords and subject
116 headings were collected and compared with keywords already utilized. The

117 Principal Investigator and Librarian then engaged in an iterative search process to
118 further develop the search.
119

120 **Contacts (Researchers contacted for additional information):**

121 No industry contacts were utilized.
122

123 **Additional Methodologies Not Listed Above:**

124 No additional methodologies to mention
125

126 **Process:** Ex. authors also utilized another resource not mentioned above to
127 garner more unpublished literature.
128

129 **Limits and Restrictions**

130

131 *Date and Time Period:* 2000 - Current

132

133 *Language:* English

134 *Publication status:* Studies, reviews, Conference Proceedings

135

136 *Species Included:* Dairy Cows

137

138 *Study Design:* observational, prospective, retrospective, reviews

139

140 *Database Subset:* None

141

142 *Pre-specified cut-off or saturation point for results:* Not applied

143

144 *Other Restrictions:* None

145

146 **Search Filters:**

147

Database	Interface	Search Filters Applied
CAB Abstracts	Cab Direct	<u>yr:[2000 TO 2020] AND Language=English</u>
Medline	PubMed	(english[Filter]) AND (2000:2020[pdat])

Scopus	Scopus	(LIMIT-TO (PUBYEAR , 2020) OR LIMIT-TO (PUBYEAR , 2019) OR LIMIT-TO (PUBYEAR , 2018) OR LIMIT-TO (PUBYEAR , 2017) OR LIMIT-TO (PUBYEAR , 2016) OR LIMIT-TO (PUBYEAR , 2015) OR LIMIT-TO (PUBYEAR , 2014) OR LIMIT-TO (PUBYEAR , 2013) OR LIMIT-TO (PUBYEAR , 2012) OR LIMIT-TO (PUBYEAR , 2011) OR LIMIT-TO (PUBYEAR , 2010) OR LIMIT-TO (PUBYEAR , 2009) OR LIMIT-TO (PUBYEAR , 2008) OR LIMIT-TO (PUBYEAR , 2007) OR LIMIT-TO (PUBYEAR , 2006) OR LIMIT-TO (PUBYEAR , 2005) OR LIMIT-TO (PUBYEAR , 2004) OR LIMIT-TO (PUBYEAR , 2003) OR LIMIT-TO (PUBYEAR , 2002) OR LIMIT-TO (PUBYEAR , 2001) OR LIMIT-TO (PUBYEAR , 2000)) AND (LIMIT-TO (LANGUAGE , "English"))
Biosis	Web of Science	Refined by: LANGUAGES: (ENGLISH) AND PUBLICATION YEARS: (2020 OR 2001 OR 2019 OR 2000 OR 2018 OR 2017 OR 2016 OR 2015 OR 2014 OR 2013 OR 2012 OR 2011 OR 2010 OR 2009 OR 2008 OR 2007 OR 2006 OR 2005 OR 2004 OR 2003 OR 2002 OR 2001 OR 2000) [excluding] DOCUMENT TYPES: (BOOK CHAPTER MEETINGS AND PATENTS)
Agris	FAO	Lmit to English AND years 2000-2020

148

Full Search Strategy:

149

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Search Database:CABDirect

151

Search ID	Terms (copy and paste)	Results
#1 cows	od:(“cattle” OR “Holstein-Friesian” OR “Holstein%20(cattle%20breed)” or “Simmental” OR “Jersey%20(cattle%20breed)” OR “American%20Brown%20Swiss” or “Ayrshire” or “Guernsey%20(cattle%20breed)”) OR de:(“cows” OR “dairy cows”) OR up:(“bos”) OR ti:(“cow” OR “cattle” OR “holstein-friesian” OR “holstein” OR “jersey” OR “cows” OR “heifer” OR “heifers” OR “simmental” OR “ayrshire” OR “guernsey” OR “brown swiss” OR “B. taurus” OR “B. Indicus” OR “bos”) OR ab:(“cow” OR “cows” OR “heifer” OR “heifers” OR “cattle” OR “holstein-friesian” OR “holstein” OR “simmental” OR “jersey” OR “ayrshire” OR “guernsey” OR “brown swiss” OR “B. taurus” OR “B. Indicus” OR “bos”)	624,883
#2 automated milking systems	de:(“machine%20milking” OR “milking%20robots” OR “automation” OR “automatic control”) OR id:(“automatic%20milking” or “automatic%20milking%20systems”)OR ti:(“Automatic milking system” OR “machine milking” OR “automated milking system” OR “automatic milking systems” OR “automated milking systems” OR automat* near/4 milking OR “voluntary milking system” OR robot* Near/2 milking OR “robotic milking system” OR “robotic milking systems” OR “AMS”) OR ab:(“Automatic milking system” OR “automated milking system” OR “automatic milking systems” OR “automated milking systems” OR “voluntary milking system” OR “robotic milking system” OR “milking machine” OR “AMS”)	29,471

#7	#1 AND #2	6,221
#8	#7 AND English AND 2000-2020	2,283
#9 Bridge	#7 AND ((year:(("2022" OR "2021"))) (language:(("English")))	264
#10 copy and paste search	(od:(("cattle" OR "Holstein-Friesian" OR "Holstein (cattle breed)" OR "Simmental" OR "Jersey (cattle breed)" OR "American Brown Swiss" OR "Ayrshire" OR "Guernsey (cattle breed)") OR de:(("cows" OR "dairy cows") OR up:(("bos") OR ti:(("cow" OR "cows" OR "heifer" OR "heifers" OR "cattle" OR "holstein-friesian" OR "holstein" OR "jersey" OR "simmental" OR "ayrshire" OR "guernsey" OR "brown swiss" OR "B. taurus" OR "B. Indicus" OR "bos") OR ab:(("cow" OR "cows" OR "heifer" OR "heifers" OR "cattle" OR "holstein-friesian" OR "holstein" OR "simmental" OR "jersey" OR "ayrshire" OR "guernsey" OR "brown swiss" OR "B. taurus" OR "B. Indicus" OR "bos"))) AND (de:(("machine milking" OR "automation" OR "automatic control" OR "milking robots") OR id:(("automatic milking" OR "automatic milking systems") OR ti:(("Automatic milking system" OR "machine milking" OR "automated milking system" OR "automatic milking systems" OR "automated milking systems" OR automat* near/4 milking OR "voluntary milking system" OR robot* Near/2 milking OR "robotic milking system" OR "robotic milking systems" OR "AMS") OR ab:(("Automatic milking system" OR "automated milking system" OR "automatic milking systems" OR "automated milking systems" OR "voluntary milking system" OR "robotic milking system" OR "milking machine" OR "AMS"))) yr:[2000 TO 2020])	

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Search Database: PubMed

Search ID	Terms (copy and paste)	Results
#1 species	"cow"[tiab] OR "cows"[tiab] OR "heifer"[tiab] OR "heifers"[tiab] OR "cattle"[tiab] OR "holstein-friesian"[tiab] OR "holstein"[tiab] OR "simmental"[tiab] OR "jersey"[tiab] OR "ayrshire"[tiab] OR "guernsey"[tiab] OR "brown swiss"[tiab] OR "B. taurus"[tiab] OR "B. Indicus"[tiab] OR "bos"[tiab] OR "cattle"[mesh]	394,363
#2 AMS	("Automatic milking system"[tiab] OR "automated milking system"[tiab] OR "Automatic milking systems"[tiab] OR "automated milking systems"[tiab] "voluntary milking system"[tiab] OR "robotic milking system"[tiab] OR "milking machine"[tiab] OR "AMS"[tiab] OR "milking robot"[tiab]) AND ("Dairying/instrumentation"[Mesh] OR "dairy"[tiab])	7,020
#4	#1 AND #2	764

#5	#4 AND (english[Filter])	700
#6	#5 AND 2000-2020	531
#7	#1 AND #2	738
#8	#7 AND English and 2000-2020	509
#9	#7 AND (english[Filter]) AND (2021:2022[pdat])	55
#10 copy and paste search	("cow"[tiab] OR "cattle"[tiab] OR "holstein-friesian"[tiab] OR "holstein"[tiab] OR "simmental"[tiab] OR "jersey"[tiab] OR "ayrshire"[tiab] OR "guernsey"[tiab] OR "brown swiss"[tiab] OR "B. taurus"[tiab] OR "B. Indicus"[tiab] OR "bos"[tiab] OR "cattle"[mesh]) AND ("Automatic milking system"[tiab] OR "automated milking system"[tiab] OR "Automatic milking systems"[tiab] OR "automated milking systems"[tiab] "voluntary milking system"[tiab] OR "robotic milking system"[tiab] OR "milking machine"[tiab] OR "AMS"[tiab] OR "Dairying/instrumentation"[Mesh]) AND ((english[Filter]) AND (2000:2020[pdat]))	

156

157

Search Database: Scopus

Search ID	Terms (copy and paste)	Results
#1 Cows	TITLE-ABS-KEY ("cow" OR "cows" OR "cattle" OR "holstein-friesian" OR "holstein" OR "jersey" OR "simmental" OR "ayrshire" OR "guernsey" OR "brown swiss" OR "B. taurus" OR "B. Indicus" OR "bos" OR "cows")	533,115
#2	(TITLE-ABS-KEY ("Automatic milking system" OR "machine milking" OR "automated milking system" OR "automatic milking systems" OR "automated milking systems" OR automat* W/2 milk* OR "voluntary milking system" OR robot* W/2 milk* OR "robotic milking system" OR "milking robot")	247,360
#3	#1 AND #2	3,514
#4	#3 AND (LANGUAGE , "English")	2,917

#5	#4 AND (LIMIT-TO (PUBYEAR , 2020) OR LIMIT-TO (PUBYEAR , 2019) OR LIMIT-TO (PUBYEAR , 2018) OR LIMIT-TO (PUBYEAR , 2017) OR LIMIT-TO (PUBYEAR , 2016) OR LIMIT-TO (PUBYEAR , 2015) OR LIMIT-TO (PUBYEAR , 2014) OR LIMIT-TO (PUBYEAR , 2013) OR LIMIT-TO (PUBYEAR , 2012) OR LIMIT-TO (PUBYEAR , 2011) OR LIMIT-TO (PUBYEAR , 2010) OR LIMIT-TO (PUBYEAR , 2009) OR LIMIT-TO (PUBYEAR , 2008) OR LIMIT-TO (PUBYEAR , 2007) OR LIMIT-TO (PUBYEAR , 2006) OR LIMIT-TO (PUBYEAR , 2005) OR LIMIT-TO (PUBYEAR , 2004) OR LIMIT-TO (PUBYEAR , 2003) OR LIMIT-TO (PUBYEAR , 2002) OR LIMIT-TO (PUBYEAR , 2001) OR LIMIT-TO (PUBYEAR , 2000)	1,872
#6	#5 AND LIMIT-TO (PUBYEAR , 2000)) AND (LIMIT-TO (LANGUAGE , "English")) AND (EXCLUDE (DOCTYPE , "ch") OR EXCLUDE (DOCTYPE , "re"))	1,775
#7 bridge search	#5 AND LIMIT-TO (PUBYEAR , 2021, 2022)) AND (LIMIT-TO (LANGUAGE , "English")) AND (EXCLUDE (DOCTYPE , "ch") OR EXCLUDE (DOCTYPE , "re"))	154
#6 Entire search	(TITLE-ABS-KEY ("cow" OR "cattle" OR "holstein-friesian" OR "holstein" OR "jersey" OR "simmental" OR "ayrshire" OR "guernsey" OR "brown swiss" OR "B. taurus" OR "B. Indicus" OR "bos" OR "cows")) AND ((TITLE-ABS-KEY ("Automatic milking system" OR "machine milking" OR "automated milking system" OR "automatic milking systems" OR "automated milking systems" OR automat* W/2 milk* OR "voluntary milking system" OR robot* W/2 milk* OR "robotic milking system") OR TITLE-ABS-KEY ("robotic milking systems" OR "AMS"))) AND (LIMIT-TO (PUBYEAR , 2020) OR LIMIT-TO (PUBYEAR , 2019) OR LIMIT-TO (PUBYEAR , 2018) OR LIMIT-TO (PUBYEAR , 2017) OR LIMIT-TO (PUBYEAR , 2016) OR LIMIT-TO (PUBYEAR , 2015) OR LIMIT-TO (PUBYEAR , 2014) OR LIMIT-TO (PUBYEAR , 2013) OR LIMIT-TO (PUBYEAR , 2012) OR LIMIT-TO (PUBYEAR , 2011) OR LIMIT-TO (PUBYEAR , 2010) OR LIMIT-TO (PUBYEAR , 2009) OR LIMIT-TO (PUBYEAR , 2008) OR LIMIT-TO (PUBYEAR , 2007) OR LIMIT-TO (PUBYEAR , 2006) OR LIMIT-TO (PUBYEAR , 2005) OR LIMIT-TO (PUBYEAR , 2004) OR LIMIT-TO (PUBYEAR , 2003) OR LIMIT-TO (PUBYEAR , 2002) OR LIMIT-TO (PUBYEAR , 2001) OR LIMIT-TO (PUBYEAR , 2000)) AND (LIMIT-TO (LANGUAGE , "English")) AND (EXCLUDE (DOCTYPE , "ch") OR EXCLUDE (DOCTYPE , "re"))	

158

159

Search Database: Biosis

Search ID	Terms (copy and paste)	Results
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#1 Cows	TOPIC: ("cow" OR "heifer" OR "heifers" OR "cattle" OR "holstein-friesian" OR "holstein" OR "jersey" OR "simmental" OR "ayrshire" OR "guernsey" OR "brown swiss" OR "B. taurus" OR "B. Indicus" OR "bos" OR "cows")	352,590
#2 AMS	TOPIC: ("Automatic milking system" OR "machine milking" OR "automated milking system" OR "automatic milking systems" OR "automated milking systems" OR "voluntary milking system" OR "robotic milking system") OR TOPIC: ("robotic milking systems" OR "AMS") OR TOPIC: (robot* near/2 milk*) OR TOPIC: (automat* near/4 milk*)	7,838
#3	#1 AND #2	1,358
#4	#3 Refined by: LANGUAGES: (ENGLISH)	1,221
#5	#4 AND PUBLICATION YEARS: (2020 OR 2001 OR 2019 OR 2000 OR 2018 OR 2017 OR 2016 OR 2015 OR 2014 OR 2013 OR 2012 OR 2011 OR 2010 OR 2009 OR 2008 OR 2007 OR 2006 OR 2005 OR 2004 OR 2003 OR 2002 OR 2001 OR 2000)	882
#6	#5 [excluding] DOCUMENT TYPES: (BOOK CHAPTER MEETINGS AND PATENTS)	811
#7 Bridge search	#4 AND #6 AND PUBLICATION YEARS: (2021 OR 2022)	94

160

161

Search Database: PubAG

Search ID	Terms (copy and paste)	Results
#1	Fields:"automatic milking system" OR "robotic milking system" OR automatic milking systems" OR "robotic milking systems"	254
#2 bridge search	AND limit years (2021-2022)	33

162

163

Search Database: AGRIS

Search ID	Terms (copy and paste)	Results
#1	automated milking systems" OR "automated milking system" OR robotic milking system" OR "robotic milking systems" AND English ter	39

#2	imited to years 2000-2020	31
#3 Bridge search	AND Limit to years 2021-2022	15

164

165 **Updates:** Updated Search 22 August 2022. Updated criteria utilized prior to
 166 screening to exclude grazing cattle literature in Protocol. Protocol revision
 167 uploaded 31 May 2023.
 168

169 **Search Designers:**

170 Information Specialists or Librarians involved in process were: Erik Fausak
 171 Principle Investigator developing search with Information Specialist: Camila Flavia
 172 de Assis Lage
 173

174 **Peer Review:**

175 Librarian shared search strategy with Systematic Review Service for broad
 176 suggestions (10 December 2020) and PRESS Checklist for Systematic Review
 177 Searching was completed by Information Specialist, Amy Studer, 22 December
 178 2020.
 179
 180
 181

Total Records	Total Records after deduplication	Deduplication software/methodology
5783	4850	Zotero
4850	3863	Covidence
Bridge Search		
615	443	Sciwheel
443	429	Covidence

182 *2.5.Selection of sources of evidence*

183 Study selection will be conducted in Covidence®. Eligibility will be assessed by
 184 two reviewers working independently, first based on the title/abstract and then, for
 185 studies identified as potentially eligible, based on the full text. A third reviewer will
 186 be consulted in case of any disagreement. The screening form for both, title/abstracts

187 and full text screening will be revised and tested for all authors before screening
188 begins. The title/abstract form will comprise of the following questions:

189 **Title/Abstract Screening:**

Inclusion Criteria	Exclusion Criteria
A study with automatic milking systems in dairy cows' operations	Not about automatic milking systems
Is this a primary study or a systematic review or scoping review?	Does not include dairy cows
The article is in English	Is this a review article (expert opinion) or not a study (or evidence-based synthesis of studies like a systematic review and scoping review)

190

191 **Full Text Review:**

Inclusion Criteria	Exclusion Criteria
The study is at least 500 words	Less than 500 words
The study does <u>not</u> involve grazing cattle.	The study involves grazing cattle exclusively.
Is the study entirely in English	Does not include dairy cows

Formatted: Underline

Describe Automated Milking System	Is this a review article (expert opinion) or not a study (or evidence-based synthesis of studies like a systematic review and scoping review)
Is this a primary study or a systematic review or scoping review?	

192

193 The total number of articles originating from each database searched, the number
 194 of unique citations following de-duplication, the number of studies assessed for eligibility
 195 based on the titles and abstracts, and number of studies assessed for eligibility based on
 196 review of the full-text screening (with reasons for exclusions at this stage) will be reported
 197 in a PRISMA Flow Diagram (Moher et al., 2009).

198 *2.6. Data charting process*

199 Data charting will be conducted in Covidence® by two reviewers working
 200 independently. The data charting form will be pre-tested by all reviewers and, if
 201 necessary, modifications will be made for question clarity. A third reviewer will be
 202 consulted in case of any disagreement. Authors will not be contacted for clarification or
 203 to obtain additional information on eligible studies. If an article describes more than one
 204 study, the data will be charted at the article level (i.e., information from all studies within
 205 an article will be extracted into a single Covidence® form).

206 *2.7. Data items*

207 The proposed information that will be extracted from each eligible article for data
208 charting is summarized as follows. Additional response options for the charting questions
209 may be included as the review evolves:

- 210 • Country(ies) where study was conducted
 - 211 • Number of farms evaluated
 - 212 • Number of AMS evaluated
 - 213 • Brand of the AMS
 - 214 • Type of traffic
 - 215 • Type of cow housing
 - 216 • Type and amount of feed provide to the cows
 - 217 • Feeding frequency
 - 218 • Length of data collection period
 - 219 • Total of cows enrolled in the study and cows milked/AMS
 - 220 • Average milking/day
 - 221 • Breed of cows
 - 222 • Milking efficiency indexes available
- 223 Purpose of the study
- 224 • Health
 - 225 • Longevity / culling
 - 226 • Milk yield, production, quality, yield per robot
 - 227 • Labor
 - 228 • Reproduction
 - 229 • Nutrition
 - 230 • Behavior / welfare

231 The study results from eligible studies will not be extracted, as this is a scoping review.

232 2.8. *Critical appraisal of individual sources of evidence*

233 A critical appraisal of the literature will not be conducted, as this is a scoping
234 review.

235 2.9. Synthesis of results

236 Descriptive statistics will be used to summarize the results of the data charting. The
237 summaries will be presented using text, tables, and figures. Research gaps will be
238 identified if present, and a narrative summary of research areas with potentially sufficient
239 bodies of evidence to support systematic reviews will be provided.

240 **Funding**

241 This project is funding by the California Dairy Research Foundation project # P-20-003-
242 UCD-FF-SR.

243 **References**

244 Jacobs, J.A. and Siegford, J.M., 2012. Invited review: The impact of automatic
245 milking systems on dairy cow management, behavior, health, and welfare. *Journal of*
246 *dairy science*, 95(5), pp.2227-2247.

247 Arksey, H. and O'Malley, L., 2005. Scoping studies: towards a methodological
248 framework. *International journal of social research methodology*, 8(1), pp.19-32.

249 Tricco, A.C., Lillie, E., Zarin, W., O'Brien, K.K., Colquhoun, H., Levac, D.,
250 Moher, D., Peters, M.D., Horsley, T., Weeks, L. and Hempel, S., 2018. PRISMA
251 extension for scoping reviews (PRISMA-ScR): checklist and explanation. *Annals of*
252 *internal medicine*, 169(7), pp.467-473.

253 Moher, D., Liberati, A., Tetzlaff, J., Altman, D.G. and Prisma Group, 2009.
254 Reprint—preferred reporting items for systematic reviews and meta-analyses: the
255 PRISMA statement. *Physical therapy*, 89(9), pp.873-880.