Supplementary Material: Impacts of climate change and heat stress on farmworkers’ health: A scoping review

Table S1: Search strategies employed in the scoping review

| **Databases** | **Strategy** | **Results** |
| --- | --- | --- |
| Medline- 1879 to December 6, 2021 | #1 Farmers/ OR (farmworker? or farm-worker? or cattlem?n or cowboy? or cowgirl? or cowhand? or cowpoke? or gaucho or shepherd? or backwoodsm?n or backwoodswom?n or boor? or bumpkin or clodhopper? or cornfed or (country adj (boy? or girl? or cousin?)) or countrym?n or countrywom?n or farmer? or hayseed or yokel or rustic or hick or ((farm\* or agricultur\*) adj3 (hand or worker? or lab?or?r?)) or grower? or peasant? or gleaner? or rancher? or breeder? or agriculturalist? or agriculturist? or agronomist? or cob or cropper? or plower? or planter? or harvester? or homesteader? or villein? or grazer? or (country adj person?) or horticulturist? or plower? or (sugarcane adj2 (cutter\* or worker\*))).mp.  #2 exp Heat Stress Disorders/ OR (((heat or heat-related) adj3 (stress or exposure or symptom? or strain or illness\* or disorder? or syndrome? or collapse? or prostration or cramp? or exhaustion? or stroke?)) or heatstroke?).mp. OR ((sun adj stroke?) or sunstroke?).mp. OR ((extreme adj (heat or temperature\*)) or (thermal adj (comfort or sensation))).mp. OR exp Climate Change/ OR (climate adj2 (chang\* or effect? or warmer or variability)).mp. OR Global warming/ OR (global adj3 warming).mp. OR Hot Temperature/ OR (heatwave\* or (heat adj wave\*) or ((hot or high or warm) adj2 (environment? or weather or temperature?)) or WBGT or "' wet bulb globe temperature").mp.  #1 AND #2 | 2115 |
| Scopus –1788 to December 6, 2021 | #1 ( TITLE ( ( farmworker\* OR farm-worker\* OR cattlem\*n OR cowboy\* OR cowgirl\* OR cowhand\* OR cowpoke\* OR gaucho OR shepherd\* OR backwoodsm\*n OR backwoodswom\*n OR boor\* OR pumpkin OR clodhopper\* OR corned OR ( country PRE/1 ( boy\* OR girl\* OR cousin\* ) ) OR countrym\*n OR countrywom\*n OR farmer\* OR mayweed OR yokel OR rustic OR hick OR ( ( farm\* OR agricultur\* ) W/3 ( hand OR worker\* OR lab\*or\*r\* ) ) OR grower\* OR peasant\* OR gleaner\* OR rancher\* OR breeder\* OR agriculturalist\* OR agriculturist\* OR agronomist\* OR cob OR cropper\* OR plower\* OR planter\* OR harvester\* OR homesteader\* OR villein\* OR grazer\* OR ( country PRE/1 person\* ) OR horticulturist\* OR plower\* ) ) OR harvester\* OR ( sugarcane W/1 ( cutter\* OR worker\* ) ) )  # 2( TITLE ( ( ( heat OR heat-related ) W/3 ( stress OR exposure OR strain OR symptom\* OR illness\* OR disorder\* OR syndrome\* OR collapse\* OR prostration OR cramp\* OR exhaustion\* OR stroke\* ) ) OR heatstroke\* OR ( sun PRE/1 stroke\* ) OR sunstroke\* OR ( climate W/3 ( effect\* OR warmer OR variability OR chang\* ) ) OR ( global W/3 warming ) OR ( extreme W/1 ( heat OR temperature\* ) ) OR ( thermal W/1 ( comfort OR sensation ) ) OR heatwave\* OR ( heat PRE/1 wave\* ) OR ( ( hot OR high OR warm ) W/2 ( environment\* OR weather OR temperature\* ) ) OR wbgt OR "wet bulb globe temperature" ) )  #1 AND #2 | 1625 |
| Web of Science- 1900 to December 6, 2021 | #1TI=(farmwORker$ OR farm-worker$ OR cattlem$n OR cowboy$ OR cowgirl$ OR cowhand$ OR cowpoke$ OR gaucho OR shepherd$ OR backwoodsm$n OR backwoodswom$n OR boOR$ OR bumpkin OR clodhopper$ OR cORnfed OR “country boy” OR “country girl” OR “country cousin” OR “country boys” OR “country girls” OR “country cousins” OR countrym$n OR countrywom$n OR farmer$ OR hayseed OR yokel OR rustic OR hick OR ((farm\* OR agricultur\*) NEAR/3 (hand OR wORker$ OR lab\*OR\*r$) ) OR grower$ OR peasant$ OR gleaner$ OR rancher$ OR breeder$ OR agriculturalist$ OR agriculturist$ OR agronomist$ OR cob OR cropper$ OR plower$ OR planter$ OR harvester$ OR homesteader$ OR villein$ OR grazer$ OR “country person” OR “country persons” OR hORticulturist$ OR plower$ OR (sugarcane NEAR/2 (cutter$ OR wORker$) ))  #2TI=(((heat OR heat-related) NEAR/3 (stress OR exposure OR symptom$ OR strain OR illness\* OR disORder$ OR syndrome$ OR collapse$ OR prostration OR cramp$ OR exhaustion$ OR stroke$) ) OR heatstroke$ OR “sun stroke” OR “sun strokes” OR sunstroke$ OR “extreme heat” OR “extreme temperature” OR “extreme temperatures” OR “thermal comfORt” OR “thermal sensation” OR (climate NEAR/2 (chang\* OR effect$ OR warmer OR variability) ) OR (global NEAR/3 warming) OR heatwave$ OR “heat wave” OR “heat waves” OR ((hot OR high OR warm) NEAR/2 (environment$ OR weather OR temperature$) ) OR WBGT OR "wet bulb globe temperature" )  #1 AND #2 | 1014 |
| CINAHL –1937 to December 6, 2021 | #1 (MH "Farmworkers") OR TI ( cattlem#n OR cowboy# OR cowgirl# OR cowhand# OR cowpoke# OR gaucho OR shepherd# OR backwoodsm#n OR backwoodswom#n OR boor# OR bumpkin OR clodhopper# OR cornfed OR (country W0 (boy# OR girl# OR cousin#)) OR countrym#n OR countrywom#n OR farmer# OR hayseed OR yokel OR rustic OR hick OR ((farm\* OR agricultur\*) N3 (hand OR worker# OR lab#or#r#)) OR grower# OR peasant# OR gleaner# OR rancher# OR breeder# OR agriculturalist# OR agriculturist# OR agronomist# OR cob OR cropper# OR plower# OR planter# OR harvester# OR homesteader# OR villein# OR grazer# OR (country W0 person#) OR horticulturist# OR plower# OR farmworker# OR farm-worker# OR (sugarcane W0 (cutter\* OR Worker\*))) OR AB ( cattlem#n OR cowboy# OR cowgirl# OR cowhand# OR cowpoke# OR gaucho OR shepherd# OR backwoodsm#n OR backwoodswom#n OR boor# OR bumpkin OR clodhopper# OR cornfed OR (country W0 (boy# OR girl# OR cousin#)) OR countrym#n OR countrywom#n OR farmer# OR hayseed OR yokel OR rustic OR hick OR ((farm\* OR agricultur\*) N3 (hand OR worker# OR lab#or#r#)) OR grower# OR peasant# OR gleaner# OR rancher# OR breeder# OR agriculturalist# OR agriculturist# OR agronomist# OR cob OR cropper# OR plower# OR planter# OR harvester# OR homesteader# OR villein# OR grazer# OR (country W0 person#) OR horticulturist# OR plower# OR farmworker# OR farm-worker# OR (sugarcane W0 (cutter\* OR Worker\*))) OR MW ( cattlem#n OR cowboy# OR cowgirl# OR cowhand# OR cowpoke# OR gaucho OR shepherd# OR backwoodsm#n OR backwoodswom#n OR boor# OR bumpkin OR clodhopper# OR cornfed OR (country W0 (boy# OR girl# OR cousin#)) OR countrym#n OR countrywom#n OR farmer# OR hayseed OR yokel OR rustic OR hick OR ((farm\* OR agricultur\*) N3 (hand OR worker# OR lab#or#r#)) OR grower# OR peasant# OR gleaner# OR rancher# OR breeder# OR agriculturalist# OR agriculturist# OR agronomist# OR cob OR cropper# OR plower# OR planter# OR harvester# OR homesteader# OR villein# OR grazer# OR (country W0 person#) OR horticulturist# OR plower# OR farmworker# OR farm-worker# OR (sugarcane W0 (cutter\* OR Worker\*)))  # 2(MH "Heat Stress Disorders+") OR TI ( (((heat OR heat-related) N2 (stress OR exposure OR strain OR symptom# OR illness\* OR disorder# OR syndrome# OR collapse# OR prostration OR cramp# OR exhaustion# OR stroke#)) OR heatstroke#)) OR AB ( (((heat OR heat-related) N2 (stress OR exposure OR strain OR symptom# OR illness\* OR disorder# OR syndrome# OR collapse# OR prostration OR cramp# OR exhaustion# OR stroke#)) OR heatstroke#)) OR MW ( (((heat OR heat-related) N2 (stress OR exposure OR strain OR symptom# OR illness\* OR disorder# OR syndrome# OR collapse# OR prostration OR cramp# OR exhaustion# OR stroke#)) OR heatstroke#)) OR TI ( ((sun W0 stroke#) OR sunstroke# OR ((extreme W0 (heat OR temperature#)) OR (thermal W0 (comfort OR sensation))) ) OR AB ( ((sun W0 stroke#) OR sunstroke# OR ((extreme W0 (heat OR temperature#)) OR (thermal W0 (comfort OR sensation))) ) OR MW ( ((sun W0 stroke#) OR sunstroke# OR ((extreme W0 (heat OR temperature#)) OR (thermal W0 (comfort OR sensation))) OR TI (climate N2 (chang# OR effect# OR warmer OR variability)) OR AB (climate N2 (chang# OR effect# OR warmer OR variability)) OR MW (climate N2 (chang# OR effect# OR warmer OR variability)) OR TI (global N2 warming) OR AB (global N2 warming) OR MW (global N2 warming) OR TI ((heatwave# OR (heat W0 wave#) OR ((hot OR high OR warm) N2 (environment# OR weather OR temperature#)) OR WBGT OR “wet bulb globe temperature”) ) OR AB ( ((heatwave# OR (heat W0 wave#) OR ((hot OR high OR warm) N2 (environment# OR weather OR temperature#)) OR WBGT OR ”wet bulb globe temperature”)) ) OR MW ((heatwave# OR (heat W0 wave#) OR ((hot OR high OR warm) N2 (environment# OR weather OR temperature#)) OR WBGT OR ”wet bulb globe temperature”)) OR (MH "Climate Change")  #1 AND #2 | 214 |
| EMBASE-1947 to December 6, 2021 | #1'heat stress'/de OR 'high temperature'/de OR 'heat stroke'/de OR 'climate change'/exp OR (((heat OR 'heat related') NEAR/3 (stress OR exposure OR symptom$ OR strain OR illness\* OR disorder$ OR syndrome$ OR collapse$ OR prostration OR cramp$ OR exhaustion$ OR stroke$)):ti,ab,kw) OR heatstroke$:ti,ab,kw OR ((sun NEXT/1 stroke$):ti,ab,kw) OR sunstroke$:ti,ab,kw OR ((extreme NEXT/1 (heat OR temperature$)):ti,ab,kw) OR ((thermal NEXT/1 (comfort OR sensation)):ti,ab,kw) OR (climate NEAR/2 (chang$ OR effect$ OR warmer OR variability)):ti,ab,kw OR (global NEAR/3 warming):ti,ab,kw OR heatwave$:ti,ab,kw OR ((heat NEXT/1 wave$):ti,ab,kw) OR (((hot OR high OR warm) NEAR/2 (environment$ OR weather OR temperature$)):ti,ab,kw) OR wbgt:ti,ab,kw OR 'wet bulb globe temperature':ti,ab,kw  #2 'agricultural worker'/exp OR farmworker$:ti,ab,kw OR 'farm worker':ti,ab,kw OR 'farm workers':ti,ab,kw OR cattlem$n:ti,ab,kw OR cowboy$:ti,ab,kw OR cowgirl$:ti,ab,kw OR cowhand$:ti,ab,kw OR cowpoke$:ti,ab,kw OR gaucho:ti,ab,kw OR shepherd$:ti,ab,kw OR backwoodsm$n:ti,ab,kw OR backwoodswom$n:ti,ab,kw OR boor$:ti,ab,kw OR bumpkin:ti,ab,kw OR clodhopper$:ti,ab,kw OR cornfed:ti,ab,kw OR ((country NEXT/1 (boy$ OR girl$ OR cousin$)):ti,ab,kw) OR countrym$n:ti,ab,kw OR countrywom$n:ti,ab,kw OR farmer$:ti,ab,kw OR hayseed:ti,ab,kw OR yokel:ti,ab,kw OR rustic:ti,ab,kw OR hick:ti,ab,kw OR (((farm\* OR agricultur\*) NEAR/3 (hand OR worker$ OR lab$or$r$)):ti,ab,kw) OR grower$:ti,ab,kw OR peasant$:ti,ab,kw OR gleaner$:ti,ab,kw OR rancher$:ti,ab,kw OR breeder$:ti,ab,kw OR agriculturalist$:ti,ab,kw OR agriculturist$:ti,ab,kw OR agronomist$:ti,ab,kw OR cob:ti,ab,kw OR cropper$:ti,ab,kw OR planter$:ti,ab,kw OR harvester$:ti,ab,kw OR homesteader$:ti,ab,kw OR villein$:ti,ab,kw OR grazer$:ti,ab,kw OR ((country NEXT/1 person$):ti,ab,kw) OR horticulturist$:ti,ab,kw OR plower$:ti,ab,kw OR ((sugarcane NEAR/2 (cutter$ OR worker$)):ti,ab,kw)  #1 AND #2 | 2315 |
| **Total Results** |  | 7283 |

Table S: Characteristics of included studies

| **Reference** | **Study Location** | **Study region** | **Study design** | **Heat exposure metric** | **Period of heat exposure** | **Study duration** | **Methods of data collection** | **Outcome assessed** | **Data analysis** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Acrury et al. 2019 | North Carolina, USA | Americas | Cross-sectional | - | May to November 2017 | 6 months | Questionnaire | Health outcome  Risk factors | Logistic regression analysis |
| Acrury et al. 2020 | North Carolina, USA | Americas | Cross-sectional | - | April to November 2017 | 7 months | Questionnaire | Health outcome  Risk factors | logistic regression model |
| Alam Shah et al. 2021 | Pakistan | Eastern Mediterranean | Cross-sectional | - | 1st January to 30th June 2019 | 6 months | Biological sampling | Health outcomes | Descriptive statistics |
| Alemu Gelaye et al. 2021 | Ethiopia | Africa | Cross-sectional | - | October to December 2019 | 3 months | Questionnaire | Health outcomes | Bivariable and multivariable binary logistic regression |
| Arcury et al. 2015 | North Carolina, USA | Americas | Cross-sectional | Heat index | August 2013 | 1 month | Questionnaire | Health outcome  Risk factors  Preventative measures | Chi-square tests |
| Arnold et al. 2020 | North Carolina, USA | Americas | Mixed methods | - | - | - | Questionnaire  In-depth interviews | Health outcome  Risk factors  Preventative measures | Thematic analysis  Descriptive statistics |
| Bethel et al. 2014 | Oregon, USA | Americas | Cross-sectional | - | July and August 2013 | 2 months | Questionnaire | Health outcome  Preventative measures | Log-binomial models  Descriptive statistics |
| Bethel et al. 2017 | Oregon/Washington, USA | Americas | Cross-sectional | - | July and August 2013 | 2 months | Questionnaire | Preventative measures | Descriptive statistics |
| Biggs et al. 2011 | South Africa | Africa | Cross-sectional | - | - | - | Biological sampling | Health outcome  Risk factors  Preventative measures | Descriptive statistics |
| Bodin et al. 2016 | El Salvador | Americas | Longitudinal | WBGT | - | - | Questionnaire  Blood sampling | Health outcome | Descriptive statistics |
| Budhathoki et al. 2019 | Nepal | Southeast Asia | Cross-sectional | - | November 2017 to January 2018 | 3 months | Questionnaire | Health outcome  Preventative measures | Descriptive statistics |
| Butler- Dawson et al. 2017 | Guatemala | Americas | Longitudinal | - | Pre-harvest:  August -November 2015  End-harvest: May 2016 |  | Questionnaire  Physiological measurements  Biological sampling |  | Multiple logistic regression  model  Multinomial logistic regression |
| Butler-Dawson et al. 2019 | Guatemala | Americas | Prospective longitudinal cohort | WBGT | February, March and April 2017 | 3 months | Questionnaire  Biological sampling | Health outcome  Risk factors | Mixed effects logistic regression analysis |
| Butler-Dawson et al. 2020 | Guatemala | Americas | Longitudinal | - | 2016–17 |  | Questionnaire  Biological sampling | Health outcomes | Multivariable linear mixed-effect models |
| CDC, 2008 | North Carolina, USA | Americas | Case report | High temperature  Relative humidity | July 2005 | 1 month | - | Health outcome | - |
| Cortez et al. 2009 | Nicaragua | Americas | Cross-sectional | WBGT | 15th April to  30th April 2008 | 15 days | Data collection sheet | Health outcome  Preventative measures | Descriptive statistics |
| Crowe et al. 2009 | Costa Rica | Americas | Qualitative | Average maximum and minimum temperature | November 2008 and March 2009 | 2 months | Observation  Exploratory interviews | Risk factors  Preventative measures | - |
| Crowe et al. 2015 | Costa Rica | Americas | Cross-sectional | - | February 2011 | 1 months | Questionnaire | Health outcome | Chi-square tests and Fisher’s exact test  Gamma statistic |
| Culp et al. 2019 | Iowa, USA | Americas | Mixed methods | WBGT | June and July | 2 months | Questionnaire  Physiological measurements | Health outcome  Risk factors | Descriptive statistics  Fisher’s test  Fisher’s exact test and Odds Ratio |
| Das et al. 2013 | India | Asia | Cross-sectional | WBGT | - | - | Physiological measurements | Health outcome | Descriptive statistics |
| Das et al. 2013 | India | Asia | Cross- sectional | WBGT |  |  | Physiological measurements | Health outcome | Descriptive statistics |
| Diniz et al. 2021 | Brazil | Americas | Cross-sectional | - | September and October 2015 | 2 months | Questionnaire  Biological sampling | Health outcomes | Descriptive statistics |
| Ekiti et al. 2018 | Cameron | Africa | Cross- sectional |  | November 2015 to May 2016 | 7 months | Questionnaire  Biological sampling  Physiological measurements | Health outcome  Risk factors | Multivariate  logistic regression model |
| Fitria et al. 2020 | Indonesia | Americas | Cross-sectional | WBGT | - | - | Questionnaire  Physiological measurements  Biological sampling | Health outcome  Risk factors | Multivariate Logistic Regression |
| Fleischer et al. 2013 | Georgia, USA | Americas | Cross- sectional |  | 2011–2012 | 2 years | Questionnaire | Health outcome  Risk factors | Population intervention models |
| Flocks et al. 2013 | Florida, USA | Americas | Qualitative | - | - |  | Focus group discussion | Health outcome  Preventive measures | Thematic analysis |
| Frimpomg et al. 2013 | Ghana | Africa | Cross- sectional | - | January to May 2013 | 5 months | Questionnaire | Health outcome | Descriptive statistics |
| Frimpomg et al. 2020 | Ghana | Africa | Cross- sectional | - | January to June 2013 | 6 months | Questionnaire | Preventive measures | Descriptive statistics |
| García-Trabanino et al. 2015 | El  Salvador | Americas | Cross- sectional | Temperature  Heat index  WBGT | March-April 2014 | 2 months | Questionnaire  Biological sampling  Physiological measurements | Health outcome  Risk factors | Multiple linear regression  logistic regression models |
| Glaser et al. 2020 | Nicaragua | Americas | Cohort |  | November 2018–April 2019 | 6 months | Questionnaire  Biological sampling | Health outcome | Regression modelling |
| Grimbuhler & Viel et al. 2021 | France | Europe | Cross-sectional | Dry-bulb temperature | 19 June to 27 June 2012 | 9 days | Questionnaire  Physiological measurements | Health outcomes  Risk factors | Multilevel regression model |
| Gun, 1995 | Australia | Western Pacific | Cross- sectional | WBGT | - | - | Physiological measurements | Health outcome  Risk factors | Multiple regression analysis |
| Hamerezaee et al. 2021 | Iran | Eastern Mediterranean | Cross-sectional | WBGT, UTCI, PHS, STI, HD, HIS | 23 July to 16 August 2016 | 25 days | Physiological measurements | Health outcomes | Descriptive statistics |
| Hansen et al. 2020 | Australia | Western Pacific | Qualitative | - | - | - | Interview | Risk factors  Preventive measures | Thematic analysis |
| Hansson et al. 2019 | Nicaragua | Americas | Cohort | WBGT | November 2017-April 2018 | 6 months | Questionnaire  Biological sampling | Health outcome  Risk factors | mixed-effects linear regression  Poisson regression |
| Hansson et al. 2020 | Nicaragua  El Salvador | Americas | Longitudinal study | - | 2014–2016  2017–2019 | - | Questionnaire  Biological sampling |  | mixed-effects logistic regression |
| How et al. 2020 | Malaysia | Western Pacific | Cross-sectional | WBGT  HSI | January to February 2019 | 2 months | Questionnaire  Biological sampling | Health outcome | Descriptive statistics |
| How et al. 2021 | Malaysia | Western Pacific | Cross-sectional | - | October to December 2019 | 3 months | Questionnaire |  | Multiple linear regression |
| Ioannou et al. 2021 | Greece/Cyprus/Qatar | Europe/Eastern Mediterranean | Cross-sectional | WBGT | - | - | Physiological measurements | Health outcomes | Linear and  non-linear regression analyses |
| Jayasekara et al., 2019 | Sri Lanka | Southeast Asia | Cross-sectional |  |  |  | Questionnaire  Biological sampling | Health outcome  Risk factors |  |
| Kearney et al. 2016 | North Carolina, USA | Americas | Cross- sectional | - | August to  September 2013 | 3 months | Questionnaire | Health outcome  Preventative measures | Logistic and log-binominal regression models |
| Kiatkitroj et al. 2021 | Thailand | Southeast Asia | Cross-sectional | - | 15 March to 11 April 2021 | 28 days | Questionnaire  Physiological measurements | Health outcomes  Risk factors | Multivariate logistic regression |
| Kupferman et al. 2018 | Nicaragua | Americas | Cross-sectional | - | Late harvest enrollment: March-May 2015 |  | Questionnaire  Physiological measurements  Biological sampling | Health outcome  Risk factors | Linear regression models |
| Kwon et al. 2015 | South Korea | Western Pacific | Cross- sectional | WBGT | July 2012 to  September 2012 |  | Questionnaire  Observation | Preventative measures | Spearman’s correlation analysis  Correlation of Kendall’s τc |
| Lam et al. 2013 | Washington, USA | Americas | Qualitative | - | - | - | Focus group discussion | Preventative measures | Thematic analysis |
| Laws et al. 2016 | Nicaragua | Africa | Longitudinal study | - | October 2010–December 2010  March 2011–May 2011 | 6 months | Biological sampling | Health outcome | Linear mixed effects models |
| Laws et al., 2015 | Nicaragua | Americas | Longitudinal | - | Pre-harvest: October -December 2010  Late-harvest: March–May 2011 |  | Questionnaire  Biological sampling | Health outcome  Risk factors | multiple linear regression models |
| López-Gálvez et al. 2021 | Mexico | Southeast Asia | Cross-sectional | WBGT | February to March 2017 | 2 months | Questionnaire  Physiological measurements  Biological sampling | Health outcomes  Risk factors | Binary logistic regression |
| Lumingu et al. 2009 | Canada | Americas | Cross- sectional | WBGT | Summers of 2004,2005, and2006 | - | Physiological measurements | Health outcome | Descriptive statistics |
| Lundgren et al. 2014 | India | Southeast Asia | Comparative | WBGT | January-February and April-May | 4 months | Physiological measurements | Health outcome  Risk factors | Descriptive statistics |
| Luque et al. 2019 | South Carolina, USA | Americas | Qualitative | - | October and December 2017 | 2 months | Focus group discussion | Risk factors  Preventive measures | Thematic analysis |
| Luque et al. 2020 | Florida and Georgia, USA | Americas | Cross- sectional | - | Between August and October 2018 | 3 months | Questionnaire | Health outcome  Preventive measures | Descriptive analysis  Multiple regression analysis |
| Mac et al. 2016 | Florida, USA | Americas | Cross- sectional | WBGT | Summers of 2012 and 2013 | - | Questionnaire  Physiological measurements | Health outcome  Risk factors | Logistic regression analysis utilizing a generalized estimating equations (GEE) approach |
| Mac et al. 2019 | Florida, USA | Americas | Cross- sectional | WBGT | Summers of 2012 and 2013 | - | Questionnaire  Physiological measurements | Health outcome  Risk factors | Logistic regression analysis  utilizing a generalized estimating equations (GEE) approach |
| Miller, 1982 | USA | Americas | Cross- sectional |  |  |  | Physiological measurements |  |  |
| Mirabelli et al. 2010 | North Carolina, USA | Americas | Cross- sectional | - | June and September 2009 | 2 months | Questionnaire | Health outcome | Log-binomial regression |
| Mitchell et al. 2017 | California, USA | Americas | Cross- sectional | WBGT | June to October of 2014 and 2015 | 8 months | Questionnaire  Physiological measurements  Biological sampling | Health outcome | Descriptive analysis |
| Mix et al. 2018 | Florida, USA | Americas | Cross- sectional | - | summers of 2015 and 2016 | - | Questionnaire  Biological sampling | Health outcome  Risk factors | Multivariable mixed modeling |
| Mohammadian et al. 2020 | Iran | Eastern Mediterranean | Cross-sectional | WBGT, ESI, DI | August to September 2017 | 2 months | Physiological measurements | Health outcomes | Descriptive statistics |
| Moyce et al. 2016 | USA | Americas | Cross-sectional | - | Summer 2014 |  | Questionnaire  Physiological measurements  Biological sampling | Health outcome  Risk factors |  |
| Moyce et al. 2017 | California, USA | Americas | Cross- sectional |  | Summer of 2014 | - | Questionnaire  Physiological measurements  Biological sampling | Health outcome  Risk factors | Logistic regression models |
| Moyce et al. 2019 | California, USA | Americas | Cross- sectional | WBGT | - | - | Questionnaire  Physiological measurements  Biological sampling | Health outcome  Risk factors | Logistic regression |
| Moyce et al. 2020 | California, USA | Americas | Cross- sectional | WBGT | Summers of 2014 and 2015 | - | Questionnaire  Physiological measurements  Biological sampling | Health outcome  Risk factors  Preventive measures | Logistic regression models |
| Mutic et al. 2018 | Florida, USA | Americas | Cross- sectional | Ambient temperature and relative humidity | summer months of 2015 to 2016 | - | Questionnaire | Health outcome  Risk factors | Multivariable logistic regression |
| Nanayakkara et al. 2020 | Sri Lanka | South east Asia | Cross-sectional |  |  |  | Questionnaire  Biological sampling |  |  |
| Nayha et al. 2017 | Finland | Europe | Cross- sectional | - | January–March 2007 | 3 months | Questionnaire | Health outcome | Logistic regression |
| Pogačar et al. 2017 | Slovenia | Europe | Cross- sectional | - | September 2016 to April 2017 | 8 months | Questionnaire | Health outcome  Preventive measures | Descriptive analysis |
| Pundee et al. 2021 | Thailand |  | Longitudinal | WBGT | Pre-harvest (March 2019) and in the late harvest (July 2019) | 6 months | Questionnaire  Physiological measurements  Biological sampling | Health outcomes  Risk factors | Linear mixed effect models |
| Quandt et al. 2008 | North Carolina, USA | Americas | Longitudinal | Average temperature | May to October 2005 | 6 months | Questionnaire | Health outcome  Risk factors | Descriptive analysis  Multivariate logistic regression |
| Raines et al. 2014 | Nicaragua | Americas | Cross- sectional design with nested case control  Analysis | - | Weekends in July–August 2012 | 8 days | Questionnaire  Physiological measurements  Biological sampling | Health outcome  Risk factors | Chi square, and univariate and multiple logistic regression |
| Rajewski et al. 2008 | Poland | Europe | Case report | - | - | - | Biological sampling  Physiological measurements | Health outcome | - |
| Raju et al. 2014 | India | Southeast Asia | Cross- sectional | - | January 2011 to December 2012 | 24 months | Biological sampling | Health outcome | Descriptive analysis |
| Ricco et al. 2017 | Italy | Europe | Cross- sectional | - | March 2017 | 1 month | Questionnaire | Health outcome  Preventive measures | Binary logistic regression analysis |
| Sadiq et al. 2019 | Nigeria | Africa | Cross- sectional | WBGT | July to September, 2016 | 3 months | Questionnaire | Health outcome | Descriptive statistics |
| Sahu et al. 2013 | India | South east Asia | Cross- sectional | WBGT | April to June 2011 | 3 months | Questionnaire  Physiological measurements | Health outcome | Descriptive statistics |
| Sandsund et al.2021 | Norway | Europe | Cross-sectional | - | - | - | Questionnaire  Physiological measurements | Health outcomes | Descriptive statistics |
| Sen et al. 2019 | India | South east Asia | Cross- sectional | WBGT, HI, HD, UTCI, SET, PMV | November to April 2015 to 2017 | 18 months | Questionnaire  Physiological measurements | Health outcome | Descriptive statistics |
| Silpasuwan et al. 2020 | Thailand | Southeast Asia | Cross-sectional | - | - | - | Questionnaire | Health outcomes | Descriptive statistics |
| Smith et al. 2020 | Georgia, USA | Americas | Cross- sectional | Maximum daily heat index  Relative humidity | - | - | Questionnaire | Health outcome  Preventive measures | Descriptive statistics |
| Sorensen et al. 2019 | Guatemala | Americas | Longitudinal | WBGT | February, March, and April, 2017 | 3 months | Questionnaire  Biological sampling | Health outcome  Risk factors | Linear mixed-effects univariate and multivariable models |
| Spector et al. 2015 | Washington state, USA | Americas | Cross- sectional | Mean maximum daily heat indices over the past week (HImax) | July to  September 2013 | 3 months | Questionnaire | Health outcome  Risk factors  Preventive measures | Mixed-effects logistic regression |
| Spector et al. 2018 | Washington state, USA | Americas | Cross- sectional | WBGT | August and September 2015 | 2 months | Questionnaire  Physiological measurements  Biological sampling | Health outcome  Risk factors | Linear mixed models |
| Stoecklin-Marois et al. 2013 | California, USA | Americas | Cross- sectional | - | November 2008-Febrruary 2010 | 14 months | Questionnaire | Preventive measures | Multivariate logistic regression |
| Stoklosa et al. 2020 | USA | Americas | Case report |  |  |  | Physiological measurements  Biological sampling | Health outcome |  |
| Trevisan et al. 2019 | Brazil | Americas | Longitudinal study | Temperature and relative humidity | March-April 2014  July-October 2014 | 6 months | Questionnaire  Biological sampling | Health outcome | Generalized linear models |
| Vega-Arroyo | California, USA | Americas | Cross- sectional | Temperature, WBGT, and the heat index | June‐ September 2015 | 4 months | Questionnaire  Physiological measurements | Health outcome  Risk factors | Multivariate regression model |
| Venugopal et al. 2021 | India | Southeast Asia | Cross-sectional | WBGT | Once during the hot season (April–June) and once during the cool season (November–January) between 2015 to 2019 | - | Questionnaire  Physiological measurements | Health outcomes | Descriptive statistics |
| Wagoner et al. 2020 | Mexico | Americas | Cross- sectional | WBGT | March, June, and August 2016 | 3 months | Questionnaire | Health outcome | Descriptive statistics |
| Wegman et al. | El Salvador | Americas | Longitudinal | WBGT | Inland group (January 7, February  18 and April 8) Coastland group  (January 9 and April 10) |  | Questionnaire  Physiological measurements  Biological sampling | Health outcome | Multivariate linear regression models |
| Wesseling et al. 2016a | Nicaragua | Americas | Longitudinal | - | November 2012- January 2013 | 4 months | Questionnaire  Physiological measurements  Biological sampling | Health outcome | Mixed effects model  Descriptive statistics |
| Wesseling et al. 2016b | Nicaragua | Americas | Cross- sectional | - | January–  February 2013 | 2 months | Questionnaire  Physiological measurements  Biological sampling | Health outcome  Risk factors  Preventive measures | Multivariate linear regression models |
| Wilmsen et al. 2019 | Oregon, USA | Americas | Case studies | - | - | - | Interview | Health outcome  Preventive measures | Thematic analysis |

WBGT: wet bulb globe temperature; HSI: heat stress index; UTCI: Universal Thermal Climate Index; STI: Subjective Temperature Index; PSI: Physiological Strain Index; PMV: Predicted mean vote; SET: Standard Effective Temperature: HI: heat index, ESI: Environmental Stress Index, DI: Discomfort Index, PHS: Predicted heat strain, HD: Humidex

Table S: Heat related health outcomes, risk factors and preventative measures extracted from the reviewed studies

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Reference** | **Study population (sample size)** | **Gender/Age** | **Heat-related outcomes (only statistically significant in quantitative studies and all outcomes in qualitative studies)** | **Protective factor (only statistically significant in quantitative studies and all risk factors in qualitative studies)** | **Risk factor (only statistically significant in quantitative studies and all risk factors in qualitative studies)** | **Non-significant association** | **Prevalence of preventive measures** |
| Acrury et al. 2015 | Farmworkers (101)  Worked outside in extremely hot weather conditions: 68  Worked inside in extremely hot weather conditions: 18 | 101 males  Age range: 30-70 | * 35.6% of the of the total sample reported heat illness * 52.9% of the sample that worked outside in extremely hot weather conditions had at least one heat illness symptom   *HRI symptoms:*   * Sudden muscle cramps (outside extremely hot weather conditions 25% vs inside in extremely hot weather conditions 27.8%) * Nausea or vomiting (10.3% vs 22.2%) * Hot, dry skin (32.4% vs 61.1%) * Confusion (13.2% vs 22.2%) * Dizziness (16.2% vs 27.8%) |  |  |  | * Drinking more water (58.4% of total sample vs 86.8% working outside in extremely hot conditions) * Taking breaks in shaded areas (59.4% vs 88.2%) * Going to air-conditioned places (19.8% vs 29.4%) * Changing work hours (16.8 % vs 25%) * Changing work activities (13.9% vs 20.6%) * Changing hours or activities (19.8% vs 29.4%) * Changing hours and activities (10.9% vs 16.2%) |
| Acrury et al. 2019 | Latinx child  farmworkers (202) | 35 males  50 females  Age range: 10-17 | * 45.5% heat-related illness in the past year   *HRI symptoms reported:*   * 25.7% dizziness * 21.8% sudden muscle cramps * 17.3% hot, dry skin * 7.4% nausea or vomiting * 5.0% confusion * 1.5% fainting |  | *Association with greater odds of HRI:*   * Increased age (OR 1.41, 95% CI 1.18, 1.69) | • Gender  • Migrant status  • Work with adult relative  • Amount of work in last three months |  |
| Acrury et al. 2020 | Latinx child  farmworkers (202) | 76 females  126 males  Age range: 10-17 | * 45.5% of participants reported HRI |  | *Association with greater odds of HRI in bivariate models:*   * Pesticide safety training (OR 2.03, 95% CI 1.08, 3.84)   *Association with greater odds of HRI in multivariate models:*   * Oldest farmworkers aged 16-17 years (OR 4.52, 95% CI 1.93, 10.57) compared to youngest aged 10-13 years * Pesticide safety training (OR 3.26, 95% CI 1.39, 7.65) | *Bivariate models:*   * Appropriate work clothing * Safety training—tool use * Safety training—machinery * Work piece-rate * Field sanitation services * Safety/risk attitudes * Vulnerability * Work safety climate scale * Supervisor interested in doing the job fast and cheaply versus as much as possible * Supervisor doing as much as possible to do the job safety versus as much as possible   *Multivariate models:*   * Age (14–15 years versus 10–13 years) * Gender * Migrant worker * Work with adult relative * Amount of Work in Last Three Months Clothing * Safety training—tool use * Safety training—machinery * Safety/risk attitudes * Vulnerability * Work safety climate scale * Supervisor interested in doing the job fast and cheaply versus as much as possible * Supervisor doing as much as possible to do the job safety versus as much as possible |  |
| Alam Shah et al. 2021 | Farmworkers and gardeners (not specified) |  | * Sperm count, motility and morphology are much better compared to bakers and oven workers |  |  |  |  |
| Alemu Gelaye et al. 2021 | Farmworkers (950) | Mean age: 26  Male: 943  Female: 7 | * 60.9% had three or more HRI symptoms   *HRI symptoms*   * 45.1% skin rash * 21.4% painful muscle cramp/spasm * 25.8% Irritability * 40.4% Headache * 42.9% Profuse sweating * 45.1% Fatigue * 45.3% Dizziness * 56.8% Extreme weakness * 31.2% Blurred vision * 15.1% Fainting /unconscious * 47.5% Confusion /restlessness |  | *Association with injuries*   * Heat stress (AOR: 1.48, 95% CI: 1.09-1.98) |  |  |
| Arnold et al. 2020 | Latinx child farmworkers (165) | 106 males  59 females  Age range: 10-17 | * 47.8% of participants   reported at least one HRI symptom   * 22% experienced at least two symptoms   *HRI symptoms reported:*   * 29.1% dizziness * 21.8% sudden muscle cramps * 17.6% hot, dry skin * 8.5% nausea or vomiting * 6.1% confusion * 1.8% fainting | *Association with lower HRI:*   * Take extra breaks (62.0% vs. 39.7%, p= .0045) | *Association with higher HRI:*   * Older participants compared to younger (10-13, 60.8%; 14-15, 44.2%; 16-17, 23.5%, p= 0011) * Go to air-conditioned places during breaks or after work (59.6 % vs. 41.7 %,p= .0279) | * Gender * Farmworker status * Years of farm work experience * Work with older relative * Pay structure * Recipient of pay * Extra water * Breaks in shade * Hours changed * Tasks changed | * 90.9% drank extra water * 87.9 % took breaks in shaded areas * 55.8 % took extra breaks * 43% changed work hours * 34.6 % gone to air-conditioned places during breaks or after work * 10.9 % changed tasks * Some reported leaving work early |
| Bethel et al. 2014 | Farmworkers (100) | 60 males  40 females  Age range:  18-62 | * 30% of participants reported experiencing 2 or more HRI symptoms   *HRI symptoms reported:*   * 10% skin rash/skin bumps * 9% painful muscle cramps/spasms * 7% dizziness/light-headedness * 1% fainting * 24% headache * 50% heavy sweating * 14% extreme weakness/fatigue * 2% nausea/vomiting * 3% confusion * 36% none |  |  |  | * 48.3% gradually increased work hours at start of season * 73% drank water at least once per hour past week * 40% had no cooling measure at work   *Head protection usually worn at work:*   * Baseball cap (94%) * Wide brimmed hat (21.0%) * Other hat (2.0%) * Bandana (75.0%) * Hood from hooded sweatshirt (63.0%)   *Clothing usually worn at work*   * Light-colored short-sleeved shirt (9.0%) * Dark-colored short-sleeved shirt (2.0%) * Light-colored long-sleeved shirt (90.0%) * Dark-colored long-sleeved shirt (23.0%) * Shorts (4.0%) * Pants (97.0%) * Jacket (72.0%) |
| Bethel et al. 2017 | Farmworkers (197)  Oregon state: 100  Washington state: 97 | 60 males  40 females  Mean age:31.8  51 males  46 females  Mean age:40.4 |  |  |  |  | *Types of beverages consumed:*   * 98.5% water * 46.2% sports drink * 8.6% energy drink * 24.9% juice * 4.6% iced coffee or tea * 10.7% hot coffee or tea * 48.2% soda * 2% other drink * Shade structures (Oregon 26% vs. Washington 6%) * Rest stations (19% vs. 6%) * Trees (47% vs 91.8) * Fans (4% vs 2.1%) * Building with air conditioning (1% vs 0%) * Cars with air conditioning (14% vs. 3%) * Mister (3 % vs 0%) * Wet clothes (40% vs. 2.1%) * Hose (14% vs. 2%) * Jump in river or canal (1% vs 0%) * HRI training (54% vs 34%) * Gradual increase of work hours at start of season (48.3% vs 34.4%)   *Headwear usually worn at work:*   * Baseball cap (94% vs 76.3%) * Wide-brimmed hat (21% vs 22.7%) * Other hat (2% vs 0%) * Bandana (75% vs 25.8%) * Hood from hooded sweatshirt (63% vs 15.5%) |
| Biggs et al. 2011 | Forestry workers (182)  Autumn: 103  Winter:79 | 64 males  39 females  Mean range:  37  68 males  11 females  Mean range:26 | * Preshift dehydration was 43% in autumn and 47% in winter (USG > 1.020 g ml) * Significant increase (P= 0.001) in the post-shift dehydration as 64% (P = 0.001) in autumn and 63% (P=0.043) in winter * 21% in autumn and 23% in winter lost >2% of their body weight across the shift * 44% of all workers were dehydrated pre-shift(USG>1.021) * 63% of all workers were dehydrated post-shift (USG >1.020) |  |  |  |  |
| Bodin et al. 2016 | Sugarcane workers (116)  Intervention group (Inland): 56  Nonintervention group (Coastland): 60 | Intervention group:  55 males  1 female  Nonintervention group:  46 males  14 females  Age range: 18-63 | Compared to pre-intervention, in post-intervention workers reported reduction of:   * Exhaustion * Nausea * Cramps * Dry mouth * Low/dark urine * Fever * Dizziness * Disorientation * Fainting * Stomachache * Headache |  |  |  |  |
| Budhathoki et al. 2019 | Farmworkers (350) | 220 males  130 females  Age range: 38.72; 12.9 | * 37% experienced heat related health problems   *HRI symptoms reported:*   * 73% fatigue * 63% dizziness * 41% headache * 28% nausea * 24% confusion * 12% heat rash * 8.3% fainting * 8% loss of concentration * 2.3% heat strokes |  |  |  | * 96% wore broad brimmed hats or used umbrellas * 65% rescheduled their work shifts * 61% stopped their outdoor farm activities * 93% rested in the shade and slowed down their work pace * 54% drank more cold water, stayed in sheds, stayed inside the house, and used wet clothing * Bathed in cold water |
| Butler- Dawson et al. 2017 | Sugarcane workers (330) | Male: 330  Median age: 28 | * 14% at baseline had eGFR between 60 and 89 ml/min/1.73m2 and 1% < 60ml/min/1.73m2 * Cross-harvest decline in eGFR in 37% of sugarcane cutters, 31% with a decline in eGFR 1- 20% and 6% with a decline in eGFR > 20% * 3% of cutters had eGFR< 60 ml/min/1.73m2   *Decline in 0%ΔGFR:*   * Workers at Mill A had 12.03% decline in eGFR compared with workers at Mill B. * Local workers had 6.30% decline in eGFR compared to highland workers * Current smokers had 5.80% decline in eGFR compared to Never/Former smokers * Workers with pre-employment eGFR <90 had 7.31% improvement in eGFR compared with workers with an eGFR ≥ 90 |  | *Decline in kidney function (less than 0%ΔGFR):*   * Mill A (OR 2.60, 95% CI=1.39,4.80) * Local worker (OR: 2.15, 95% CI: 1.28,3.60) * Current smoker (OR: 2.33, 95% CI: 1.17,4.63)   *Severe decline (more than 20% decline) in %ΔGFR:*   * Pre-employment eGFR less than 90 (OR: 4.23, 95% CI: 1.12,15.99) * Local worker (OR: 4.37, 95% CI: 1.41,13.52) * Current smoker (OR: 5.27, 95% CI: 1.54,17.99)   *Mild decline (0% to 20% decline) in %ΔGFR:*   * Local worker (OR: 1.92, 95% CI: 1.12:3.30) * Working at Mill A (OR: 2.48, 95% CI: 1.30:4.72) |  |  |
| Butler-Dawson et al. 2019 | Sugarcane workers (517) | 517 males  Age range: >18 | * 81% of sugarcane workers had at least one AKI (indicated by increase in serum creatinine of 26.5 μmol/L or 50% or more from the pre-shift value) during the study period * AKI cumulative incidence over a work shift was 47% in February, 51% in March and 45% in April | *Association with lower AKI (univariate analysis):*   * Average WBGT (per 1 °C) (OR 0.90,95% CI 0.82, 0.98) * Maximum WBGT (per 1 °C) (OR 0.89 95% CI 0.82, 0.96) * More work shift hours (OR 0.89 95% CI 0.83, 0.95)   *Association with lower AKI (multivariate analysis):*   * Higher baseline eGFR (OR 0.98, 95% CI 0.97–0.99) * Higher electrolyte solution intake were associated (OR 0.94, 95% CI 0.89–0.99) | *Association with higher AKI (univariate analysis):*   * Age (OR 1.01, 95% CI 1.00–1.03) * Baseline eGFR (OR 0.98, 95% CI 0.98–0.99) * Pre-shift urinary-specific gravity (OR 1.41, 95%   CI 1.19–1.67)   * Post-shift specific gravity (OR 1.48; 95% CI 1.27–1.72) * Electrolyte solution intake (OR 0.89, 95% CI 0.85–0.93) * Rest breaks (OR 0.83, 95% CI 0.75–0.93) * Work shift hours (OR 0.89, 95% CI 0.83–0.95) * Job type (OR 3.10, 95% CI 2.29–4.19) * Average WBGT (OR   0.90, 95% CI 0.82–0.98   * Maximum WBGT (OR 0.89, 95% CI 0.82–0.96)   *Association with higher AKI (multivariate analysis):*   * Dehydration indicated by higher post-shift specific gravity (OR 1.24, 95% CI 1.02–1.52) * NSAIDs and increasing post shift specific gravity (OR 8.38, 95% CI 1.67–42.16) | *Univariate analysis:*   * Local home residence * Hypertension * BMI * Previous harvests * Body weight change * Specific gravity, percent change * Sugary beverage intake * Smoked cigarette * NSAID use * Alcohol intake   *Multivariate analysis:*   * Age * Hypertension * Work shift hours * Rest breaks * Pre-shift specific gravity * Average WBGT |  |
| Butler-Dawson et al. 2020 | Sugarcane Workers (105) | Mean age: 30  Male: 105 | * Average serum creatinine was 85.75 μmol/L * Average eGFR was 105.73mL/min/1.73 m2 * Average urine NGAL was 9.71 ng/mL |  | *Association with serum creatinine:*   * HbA1c (β:19.28; 95% CI: 6.73 to 31.84) * Age (β:0.43 95% CI: 0.01-0.84)   *Association with eGFR:*   * HbA1c (β: –15.59; 95% CI: –26.40 - –4.78) * Age (β: –1.13; 95% CI: –1.46 to –0.80)   *Association with urine NGAL:*   * Weight change, kg (β: 0.29 ; 95% CI: 0.01-0.57) |  |  |
| CDC, 2008 | A Hispanic worker | Male  Age: 56 | * Death due to heat stroke * Core body temperature was 42°C at time of death * The man developed confusion before death |  |  |  | * The worker had not received HRI training |
| Cortez et al. 2009 | Sugarcane workers (22) | Age not specified  Gender not specified |  |  |  |  | * Seven workers drank from 7 to 8 L as temperature increased * Although temperature increased to maximum values many workers did not follow the rehydration measures and drank less than 6 L which is considered low |
| Crowe et al. 2009 | Sugarcane field workers (sample size not specified) |  |  |  | * Temporary workers are reluctant to take breaks since they are paid by piece |  | * Most field workers take between 2 and 10 liters of water into the field with them * Most workers reported drinking either coffee or ‘fresco’ (fruit juice mixed with water and sugar) * Workers use long sleeves, long pants and neck covering |
| Crowe et al. 2015 | Sugarcane cutters (169)  Harvesters: 106  Median age: 34  Non-harvesters: 63  Median age: 37 | (gender not specified)  Median age: 34  Median age: 37 | * Heat and dehydration symptoms experienced at least once per week were significantly different between harvesters and non-harvesters (P<0.05) with the exception of vomiting and dry mouth   *HRI symptoms at least once per week:*   * Headache (harvesters 50.9% vs non-harvesters 25.4%) * Tachycardia (34.9% vs 4.8%) * Muscle cramps (24.5% vs 11.1%) * Fever (17.9% vs 3.2%) * Nausea (17% vs 0%) * Difficulty breathing (13.2% vs 0%) * Dizziness (11.3% vs 1.6%) * Swelling of hands/feet (7.5% vs 0%) * Vomiting (3.8% vs 0%) * Dry mouth (32.1% vs 22.2%) * Dysuria (28.3% vs 3.2%) * Heat and dehydration symptoms increased as heat exposure categories increased (office and various workers, field and plant workers and harvesters) |  |  |  |  |
| Culp et al. 2019 | Farmworkers (168)  Cross sectional (CS) group: 148  Intensive Surveillance (IS) Group: 20 | 168 males  Age range: 18-65 | *CS group:*   * Extreme thirst (21.9% among participants between the ages of 18-34 years 21.9% vs. 16.5% among participants equal or older than 35 years 16.5%) * Muscle cramps (7.8% vs 7.1%) * Confusion (4.7% vs 7.1%) * Light-headed or dizzy (4.7% vs 5.9%) * Nausea (4.7% vs 3.6%) * Chest pounding (3.1% vs 1.2%)   *Association with uncomfortable Physiological intensity (PI) score (0-5) PI among IS group:*   * Higher body temperature (F ratio = 16.41, p < .001) * Kilocalories per hour (F ratio=8.41, p=0.001)   *Association with uncomfortable WBGT among IS group:*   * Higher heart rate (F ratio: 4.59, p = 0.014) * Higher breathing rates (F ratio: 6.48, p = 0.003) * Higher PI scores (F ratio: 5.11, p = 0.003) |  |  |  | *CS group:*  *Types of beverages consumed:*   * 68.9% water * 19.6% soda * 4.7% sports drinks |
| Das et al. 2013a | Control and experimental group (170)  Experimental: Groundnut farmers (85)  Control: Office workers (85) | Gender not specified  Mean age: 31.9;6.82  Gender not specified  Mean age: 27.2;5.4 | *Rate at work vs. just after work*   * Heart rate:74.4 vs. 121.5 beats/min * Systolic blood pressure: 110.2 vs. 132.2 * Diastolic blood pressure: 71.9 vs. 80.1   *Rate among farmers vs. office workers*   * Maximum heart rate: 188.1 vs. 192.8 * Heart Rate Reserve: 113.8 vs. 117.7 * Net Cardiac Cost: 47.1 vs. 31.8 * Relative Cardiac Cost: 63.45 vs. 42.6 |  |  |  |  |
| Das et al. 2013b | Control and experimental group (240)  Experimental: Child agricultural workers (120)  Control (120) | 63 males  57 females  Age range: 10-16 | * Change of heart rate (workers 81.5 beat/min vs control 32.8 beat/min) * Change of systolic blood pressure (35 mmHg vs 19.3 mmHg) * Change of diastolic blood pressure (7 mmHg vs 4.3 mmHg) |  |  |  |  |
| Diniz et al. 2021 | Sugarcane Cutters (17) | Mean Age: 26  Male: 17 | * No participants had abnormal eGFRScr-Scy (eGFR calculated using both serum creatinine and cystatin C) * 2 participants had low eGFRScr (eGFR calculated using serum creatinine) * 7 participants had low Cystatin C while none had high Cystatin C |  |  |  |  |
| Ekiti et al. 2018 | Sugarcane workers (204)  Office: 23  Factory:57  Field:124 | 153 males  51 females  Mean age: 38.8;9.8 | * 3.4% of participants had CKD (indicated by proteinuria and/or GFR< 60 ml/min/1.73 m2 persistent after 3 months) * CKD prevalence was 7% in factory workers compared to 0% and 2.4% in office and field workers * 2.9% had persistent proteinuria which was mild * 0.5% had GFR < 60 ml/min/1.73 m2 |  | *Association with higher CKD:*   * Age ≥ 40 years (OR = 18.7, 95% CI = 1.5–236.4, p = 0.024) | * Sex * Contract type * Duration of employment * Socio-economic status * Exposure to agrochemicals, heavy metals and heat * Alcohol use * Chronic use of herbal medicines * Family history of CKD * Obesity and overweight * NSAID use * Tobacco use * Hypertension * Diabetes |  |
| Fitria et al. 2020 | Rice harvesters (354) | Male: 354  Age: 20-65 | * The overall prevalence of CKD was 24.9% while CKDu was 18.6%. |  | *Association with CKDu:*   * Farm location (high altitude versus low altitude location) (Prevalence Odds Ratio (POR): 2.0; 95% CI: 1.2–3.5) |  |  |
| Fleischer et al. 2013 | Farmworkers (405) | 326 males  79 females  Age range: >18 | * 1/3 reported experienced three or more symptoms in the past week * 71% experienced at least one symptom in the past week   *HRI symptoms:*   * 50.8% headache * 44.9% hot, dry skin * 33.7% sudden muscle cramps * 24.6% dizziness * 16.7% nausea or vomiting * 15.5% confusion * 4.4% fainting | *Association with a reduction in prevalence of three or more HRI symptoms:*   * Increasing breaks in the shade reduces (9.2%) * Increasing access to medical attention (7.3%) * Reducing soda intake by (6.7%) * Increasing access to regular breaks (6.0%) |  | * Go cool down * Sports drinks * Water * Time in Georgia this year * Education * Access to shade * Load/pack outside * Alcohol * Change work duties * Work days/week * Juice * Wear sunscreen * Work hours/day | *Drink more of beverage during hot conditions:*   * 95.3% water * 83.8% sports drinks * 62.6% juice * 53.5% soda * 21.6% energy drinks * 6.8% coffee or tea * 6.5% alcohol |
| Flocks et al. 2013 | Fernery and nursery workers (35) | 35 females  Age range: 18-55 | * Prevalence of general health effects include headaches, dizziness/fainting, respiratory problems, vomiting, and exacerbated high or low blood pressure |  |  |  |  |
| Frimpong et al. 2013 | Farmworkers (308) | Gender not specified  Age not specified | * Prickly heat (17% male vs 17% female) * Heat cramp (29% vs 17%) * Heat exhaustion (40% vs 23%) * Malaria (77% vs 54%) * Cerebro-spinal meningitis (23% vs 10%) |  |  |  |  |
| Frimpong et al. 2020 | Farmworkers (308) | Males: 186  Females: 122  Age not specified |  |  |  |  | * 26.6% got away to a shade for a while * 4.2% removed clothing for free air * 19.8% drank water regularly * 16.9% wore a hat * 32.5% wore of airy dress * 3.2% covered head with traditional scarf * 10.4% wore traditional cloth which is airy * 46.1% ate traditional food which induces regular intake of water * 40.3% didn’t eat traditional food |
| García-Trabanino et al. 2015 | Sugarcane cutters (189) | 168 males  21 females  Age range: 18-49 | * 20% of the men had a pre-shift serum creatinine level above 1.2 mg/dL * 27% of the men had a serum uric acid level above 7.0 mg/dL. * 14% had a pre-shift GFR less than60 mL/min/1.73 m2 * 3 workers had severely reduced eGFR (<30 mL/min) * 10% increase in serum creatinine, urea nitrogen, and uric acid during post-shift as compared to pre-shift * Mean urine specific gravity was 1.016 pre-shift and 1.020 post-shift * Increase of mean urinary creatinine from 1.1 to 1.9 g/L * 1/3 of workers lost >0.5 kg of body weight | *Association with increased GFR linear regression models:*   * Liquid intake (0.06 mg/dl decrease in serum creatinine for each dL per hour of liquid intake, P=0.07)   *Association with increase post shift body weight*   * One extra liter of fluid increased post-shift body weight with about 0.5 kg (P=0.008) | *Association with reduced GFR among* logistic regression model*:*   * Age (OR 1.09 per year, 95% CI 1.02–1.16, P=0.008) * Region – coastal region (where temperature and humidity is higher) versus the other two regions combined (OR 3.5, 95% CI 1.3–9.4, P=0.01) * Association with ever use of carbamate insecticide when replacing any use of pesticides   *Association with increased post-shift serum creatinine in multiple linear regression models:*   * WBGT (about 2% increase in serum creatinine per degree of WBGT, p=0.001) | *Logistic regression model:*   * BMI * Smoking * Kidney stones * Hypertension * NSAIDS use * Diuretics * Number of previous harvests * Any use of pesticides   *Multiple linear regression:*   * Work time * Region | * The mean liquid intake was 0.3 L at breakfast and 3.3 L during work (mean 0.8 L per hour) * 90% was water |
| Glaser et al. 2020 | Sugarcane workers  Harvest 1 (525)  Harvest 2 (567) | Mean age Harvest 2:  Field support staff (FS)  31 (7)  Irrigation repair workers (IR)  29 (7)  Seed cutters (SC): 28 (7)  Burned cane workers (BCC): 31 (8) | *After intervention is introduced:*   * Lower decline in cross harvest eGFR among BCC (6, 95% CI 2 to 9) * Lower decline in cross harvest eGFR among SC (2 −1, 4) * IKI (indicated by increase in serum creatinine by ≥0.30 mg/dL or ≥1.5 times increase from baseline to end-harvest) was 70% (95% CI 90% to 50%) lower among BCC * Seed cutter groups with the worst compliance had the most cases of IKI whereas the groups with the best compliance had only one case |  |  |  | * Workers reported larger water and boli (300 mL electrolyte solution bags) intake after intervention is introduced |
| Grimbuhler & Viel et al. 2021 | Vineyard Workers (30) | Age range: 21-59  Female: 19  Male: 11 | * Skin temperature at rest (°C) (mean 33.9 vs minimum 31.7 vs maximum 35.8) * Mean skin temperature during work (°C) (34.9 vs 32.34 vs 36.1) * Mean heart rate (bpm) (113.5 vs 78.7 vs 165.3) * Net cardiac cost (bpm) (24.1 vs 7.1 vs 62.7) * Relative cardiac cost (%) (23.1 vs 10.1 vs 87.2) * Cardiac workload score (unitless) (8.8 vs 2.0 vs 15.0) |  | *Association with skin temperature*  *at rest (°C):*   * BMI (β: 0.114, 95% CI: 0.020, 0.208)   *Association with mean skin*  *temperature during work (°C):*   * Male gender (β: 1.447; 95% CI: 0.922-1.972) * Experience in vine-lifting (β: 0.038; 95% CI: 0.009-0.067)   *Association with relative cardiac cost (%):*   * Task duration (β: 0.219; 95% CI: 0.033-0.405) * Dry-bulb temperature (°C) (β: 3.652; 95% CI: 0.888-6.416)   *Association with Net cardiac cost (bpm):*   * Experience in vine-lifting (β: −0.476 95% CI: −1.001-0.049)   *Association with Mean heart rate (bpm):*   * Dry-bulb temperature (°C) (β: 4.084; 95% CI: 0.442-7.726)   *Association with cardiac workload score:*   * Dry-bulb temperature (°C) (β: 0.644; 95% CI: −0.046-1.334) | * Age was not associated with any physiological parameters |  |
| Gun, 1995 | Sheep Shearers (43) | 43 males  Age range: 18-59 | * Daily average sweat loss was 6.1 Kg * Average dehydration was 2·8% of body mas * Drink was 72% of sweat loss * Average rectal temperature was 37.7°C * Afternoon mean values of rectal temperature exceeded 38·0°C in 4 of the l5 observations made when WBGT > TLV | *Association with decreased rectal temperature:*   * Heavier alcohol consumption was associated with 0·16°C lower (p = 0·02) rectal temperature | *Association with increased rectal temperature:*   * WBGT (Percentage of variation explained 27%, partial regression Coefficients 0·029) * Vapor pressure (16%, 0.054) * Fat free mass (4%, 0.008) * Alcohol (5%, -0.001)   *Association with sweat loss:*   * WBGT (61%, 508) * Fat free mass (16%, 116) | * Added radiant heat * Thermal environment * Body fat content | * Drinking water |
| Hamerezaee et al. 2021 | Farmworkers (87) | Mean age: 37.10  Male: 87 | * Mean systolic blood pressure was 127.24 ±14.12 mmHg * Mean diastolic blood pressure was 76.20±10.37 mmHg * Mean heart rate 75.71±12.15 was beats/min * Mean oral temperature was 36.01±0.64 °C * Mean skin temperature was 34.43±1.67 °C |  |  |  |  |
| Hansen et al. 2020 | Case study of seasonal migrant workers |  |  |  | * Cultural and language barriers to understanding safety training and instructions * Lack of ability to make autonomous decisions about their health and safety * Piece rate work encourages workers to continue working |  |  |
| Hansson et al. 2019 | Sugarcane workers (525)  Field support (low workload): 52  Irrigation workers  (moderate):128  Seed cutters (high):188  Cane cutters: (very high):157 | 394 males  131 females  Age range: 18-60 | *IKI prevalence:*   * 27% in burned sugarcane cutters * 9% in seed cutters * 2% in both field support staff and irrigation workers * eGFR decreased by 4.6 (95% CI 3.2 to 6.0) mL/ min/1.73 m2 during harvest * Of the 427 workers examined at baseline and end-harvest, 32 (7%) had IKI | *Association with lower eGFR and IKI:*   * 1-year age increase associated with a 0.96 (95% CI 0.92 to 0.99) IR decrease | *High-moderate workload groups had higher IKI:*   * Burned cane cutters (Incidence ratio 9.3, 95% CI 3.2 to 28.3) * Seed cutters (3.3, 95% CI 1.1 to 9.9)   *Association between workload and cross harvest GFR:*   * Irrigation repair and field support (mean 0; 95% CI -2,1) * Seed cutters ( -5, -7, -3) * Cane cutters (-9, -13, -6) | * Sex * Pesticide use * NSAID use * Smoking * Change in 24-hour liquid intake over harvest * Sugary beverage intake per 24 hours at end of harvest * Diabetes * Hypertension |  |
| Hansson et al. 2020 | Male Sugarcane cutters (>800) | Age range: >18 |  | *Association with reduced risk of IKI (indicated by ≥0.3 mg/dL or ≥50% increase in serum creatinine since baseline):*   * Morning boli intake (300 mL electrolyte sachets) (Incidence Ratio IR 0.5, 95% CI 0.2–0.9) | *Association with increased risk of IKI:*   * Sugary drink intake greater than 1L (IR 4.4, 95% CI 1.0–19) * NSAID use at least once per week (IR 2.1, 95% CI 1.2–3.8) | * Age |  |
| How et al. 2020 | Farmworkers (58)  Agroecology (no pesticide use): 33  Conventional rice farmers (pesticide users): 25 | 58 males  Age range: 20-60 | * Significant difference in blood pressure and blood glucose (p < 0.05) among organic and conventional farmers * Significantly higher HSI among conventional rice farmers (p < 0.001)   *Compared to agroecology farmers, conventional farmers have higher odds of:*   * Prehypertension (OR: 3.89, CI: 0.904-16.72) * Hypertension (OR: 15.0, CI: 3.153-71.367) * Prediabetes (OR: 13.75, CI: 2.86-66.03) * Diabetes (OR: 5.56, CI: 1.37–22.56) |  |  |  |  |
| How et al. 2021 | Agroecology farmworkers (91)  Conventional farmworkers (104) | Age range: 18-67  Male: 60  Female: 31  Age range: 25-76  Male: 78  Female: 26 | * The minimum and maximum number of HRI symptoms was 4 and 8 respectively among agroecology farmworkers * The minimum and maximum number of HRI symptoms was 1 and 6 respectively among conventional farmworkers |  |  |  |  |
| Ioannou et al. 2021 | *Observational studies*  Agricultural workers (36)  *Interventional studies*  Agricultural workers (Cyprus) (6)  Agricultural workers (Qatar) (34) |  | *Intervention studies (Cyprus)*   * Use of mechanical fruit cart and improved work/rest ratio did not lower core temperature, skin temperature and heart rate * Use of ventilated garments reduced skin temperature (p = 0.009; d = -1.59) without impacting core temperature and heart rate   *Intervention studies (Qatar)*   * Hydration strategy increased heart rate (p = 0.009; d = 0.69) without affecting core temperature and skin temperature * Use of evaporative garments had no effect on core temperature, skin temperature and heart rate * Improved breaks increased heart rate (p = 0.006; d = 0.84) without affecting core temperature and skin temperature |  | *Association with skin temperature:*   * WBGT (R2 = 0.941; F(1,10) = 159.098, p < 0.001) | * No association was identified between WBGT and core temperature of agriculture workers |  |
| Jayasekara et al. 2019 | Agricultural workers (257)  No CKD or diabetes (DM) group: 216  CKD or DM group: 41  Mean age: 53.73 ± 11.20 | Mean age: 46.59;13.02  Mean age: 53.73;11.20 | *Workers reporting CKD or DM had:*   * Higher heat stress and dehydration symptom index (10.78 vs. 8.03, p < .01) * Higher (Urine albumin-creatinine ratio) ACR > 30 (85.4% vs. 69.4%, p < .05)   *Among workers with no CKD or DM group:*   * ACR > 30 (high-prevalence CKD region 72.2% vs low prevalence region 55.6%, p < .05) * Higher index (8.4 vs. 6.1, p < .001) | *Association with lower index:*   * Higher income (2.1 fewer points on the index, p < .05) | *Association with higher index:*   * Female status (3.1 additional points on the index, p=.001) | * Age * Average water intake (l) * BMI * ACR > 30 |  |
| Kearney et al. 2016 | 158 farmworkers | 154 males  1 female  Age range: > 18 | * 72% of farmworkers experienced at least one HRI symptom * 27% of farmworkers had three or more HRI symptoms   *HRI symptoms reported:*   * 43.6% headache * 37.6% heavy sweating * 35.7% muscle cramps or spasms * 17.9% weakness or fatigue * 13.5% dizziness or light headedness * 12.1% rash/bumps * 8.5% nausea or vomiting * 4.3% fainting * 1.4% confusion * 5.0% other symptoms or illness during a hot day at work | *Associated with reduced HRI (≥3 Symptoms):*   * Wearing long-sleeved shirts (Prevalence ratio (PR) 0.89, 95% CI: 0.32, 2.51), * Limiting time in sun (PR 0.97 95% CI: 0.46, 2.07) * Wearing sunglasses (PR 0.84, 95% CI:0.33, 2.16) * Wearing long pants (PR 0.35, 95% CI: 0.02, 7.67) | *Associated with increased HRI (≥3 Symptoms):*   * Wearing sunscreen (PR 3.08, 95% CI: 0.87, 10.92) * Wearing a hat (PR 1.39, 95% CI:0.16, 11.87) * Wearing a shirt with collar (PR 1.30, 95% CI: 0.46, 3.62) * Protection over face (PR 1.24, 95% CI: 0.59, 2.60) | * Gloves | *Sun safety behavior used often or always:*   * 98.1% wore long pants * 92.9% wore head protection (baseball hat, cap, or visor) * 27.5% wore a wide-brim hat * 85.8% wore a long-sleeved shirt or blouse * 79.4% wore a shirt with a collar * 56.3% wore gloves * 15.6% wore any protective gear over face * 11.2% wore sunglasses * 9.1% wore sunscreen |
| Kiatkitroj et al. 2021 | Sugarcane farmers (200) | Mean age: 54.9  Male: 79  Female: 121 | * 48% had HRI symptoms * 30.4% of men reported HRI compared to 59.5% of females   *HRI symptoms*   * 81.5% heavy sweating * 71.5% weakness/fatigue * 60% dizziness * 55.5% muscle cramps * 52.0% headache * 51.5% vertigo * 40.5% rash on skin * 36.0% irritability * 18.5% nausea * 16.5% dry and cracking skin * 15% vomiting * 10.5% swelling hands and feet * 9.0% blisters on skin * 4.0% fainting * 7.5 other abnormal symptom | *Association with HRI symptoms*   * Fluid intake 3.1–5.0 L/day (OR: 0.23; 95% CI: 0.09–0.56)   *Association with HRI symptoms*   * Fluid intake of 3.1–5.0 L per day (OR: 0.21, 95% CI: 0.07–0.60) | *Association with HRI symptoms (Univariate analysis):*   * Female sex (OR = 3.37, 95% CI: 1.85–6.141) * Duration of heat exposure ≥ 5 hours/day (OR = 1.88, 95% CI: 1.02–3.44) * Afternoon napping > 60 minutes (OR:2.55, 95% CI: 1.08–5.98) * Wear two long-sleeved shirts (OR: 7.54, 95% CI: 2.92–19.44) * Wear short-sleeved and a long-sleeved shirt (OR: 5.23, 95% CI: 2.23–10.78) * Wear two-layer pants (OR: 2.25, 95% CI: 1.07–4.74)   *Association with HRI symptoms (multivariate analysis):*   * Female sex (OR: 2.37: 95% CI: 1.11–5.04) * Wear two long-sleeved shirts (OR: 5.24, 95% CI: 1.69–16.24) compared to one long-sleeved shirt * Wear short-sleeved and a long-sleeved shirt (OR: 3.61, 95% CI: 1.52–8.53) compared to one long-sleeved shirt | *Univariate analysis:*   * Age * Work experience * Fat * Total Body water * Alcohol consumption * Caffeine intake * Smoking * Hours of sleeping * Duration of heat exposure (<5 hours/day) * Afternoon napping (<60 minutes) * Fluid intake (1-3 L/day) * Wear one-layer polyester or jean pants * Full face mask * Head protection   *Multivariate analysis:*   * Duration of heat exposure * Afternoon napping * Fluid intake (1-3 L/day) * Wear one-layer or two layer pants | * 36.5% consume 1 to 3 L of fluid per day * 50% consume 3.1 to 5 L of fluid per day   13.5% consume more than 5 L of fluid per day |
| Kupferman et al. 2018 | Sugarcane workers (326)  Cane cutters: 153  Seeders/ seed cutters: 59  Weeders: 35  Pesticide applicators:25  Irrigators:54  First follow-up: 29 | Male: 326  Age 18-60 | * 34 participants (10.4%) had AKI * 19.0% of cane cutters had AKI compared with 2.9% performing other job tasks (P < 0.001) * Median serum creatinine (SCr) of the 34 AKI workers was 1.64 vs non-AKI workers 0.88 mg/dL * AKI workers had an increase in median SCr to 1.25 and 1.27 after 6 and 12-month follow-up respectively * 10 participants (34.5%) with AKI developed eGFR < 60 and 11 (37.9%) had >30% decrease in eGFR at 12-month follow-up |  | *Association with higher serum creatinine levels:*   * Job as cane-cutter vs other (eβ 1.20, 95% CI 1.13-1.27)   Addition of pre-harvest Scr level to the model:   * Job as cane-cutter vs other 1.16 eβ, 95% 1.10-1.22) |  |  |
| Kwon et al. 2015 | Farmers (120) | 49 males  71 females  Age: 61;11.6 |  |  |  |  | *Farmworkers wear less clothing with higher WBGT:*   * Clothing insulation (χ2 = 390.923, df = 344, p = 0.041) and had a correlation with WBGT (τ = −.191) * Number of layers for Upper clothing (χ2 =27.880, df = 16, p = 0.033) and had a correlation (τ = −.257) * Footwear (χ2 = 67.726, df = 40, p =0.004) and had correlation (τ = −.123) |
| Lam et al. 2013 | Latino farmworkers (35) | 21 males  14 females  Age range: > 18 |  |  |  |  | * In addition to water participants also reported drinking energy drinks to increase alertness and productivity * Workers identified removal of clothing layers as an HRI preventive measure * Female participants also reported wearing darker clothing and layered clothes to sweat to lose weight |
| Laws et al. 2016 | Sugarcane workers (284) | 251 males  33 females  Age range: 18-63 | * eGFR was 113 mL/min/1.73 m2 * <5% of workers had albuminuria * Men had NGAL and IL-18 levels that were about one-third those of women at both the pre- and late harvest * Increase in NGAL levels among cane cutters (preharvest 7.6 ug/g, late harvest 19.3) * Decrease in NAG levels in factory workers (preharvest 2.23, late harvest 0.60) | *Consumption of electrolyte packet among cane cutters:*   * 23% decrease in mean NGAL (RM, 0.77; 95% CI, 0.61-0.98) * 16% decrease in mean NAG (RM 0.84 95% CI 0.70-1.01)   *Consumption of electrolyte packet among seed cutters:*   * 31% decrease in mean IL-18 (RM 0.69 95% CI, 0.46-1.04)   33% decrease in mean NAG (RM 0.67 95% CI 0.44-1.02) | *Association with higher NGAL among all workers:*   * Cane cutters (RM, 2.57; 95% CI, 1.54-4.27) * Irrigators (RM, 2.07; 95% CI, 1.24-3.47) * Field workers (RM, 1.49; 95% CI, 1.06-2.09) compared to non-field workers   *Association with higher IL-18 among all workers:*   * Field workers (RM 1.61; 95% CI, 1.12-2.31) compared to non-field workers * Cane cutters (RM, 1.89 95% CI 1.08-3.29) * Seeders (RM, 2.11; 95% CI 1.14-3.92) | * Agrichemical applicators did not have increases in kidney injury biomarkers compared to other field workers * No overall association between self-reported daily intake of water or electrolyte solution and NGAL, IL-18, or NAG |  |
| Laws et al., 2015 | Sugarcane workers (284)  Cane cutters (51)  Seeders (36) Seed cutters (19) Agrochemical applicators (29)  Irrigators (49)  Drivers (41) Factory workers (59) | Male: 251  Female: 33  Age: 18-63 | *Cross harvest eGFR* (*ml/min/1.73):*   * Decline in cross harvest eGFR among field workers (-6.9 ml/min) compared to non-field workers * Decline in cross harvest eGFR among seed cutters (-8.6), irrigators (-7.4), cane cutters (-5.0) compared to factory workers * Fewer than 5% of workers had albumin-to-creatinine ratio (ACR) >30 mg/g | *Late harvest eGFR:*   * Consumption of electrolyte packet among cane cutters (6.1 ml/min/1.73 m2; 95% CI: 20.06, 12.2)   *Cross harvest eGFR:*   * Consumption of electrolyte packet among cane cutters (7.0 ml/min/1.73 m2; 95% CI: 1.9, 12.1) | *Decline in pre-harvest eGFR:*   * Number of years employed at the company (0.3 ml/min/1.73 m2 95% CI: 20.6, 20.04) |  |  |
| López-Gálvez et al. 2021 | Farmworkers (101)  Organic fields: 50  Conventional fields: 51  Reference group (50) | Age range: 18-59  Male: 101  Age range: 18-59  Male: 50 | * One farmworker developed kidney disease, two suffered a kidney injury, and 14 were at risk of a kidney injury * Decline in eGFR from pre-harvest (125 ± 13.0) to late harvest (106 ± 17.5) among farmworkers * Significant decline in eGFR among conventional field (101.2 ± 19.4) compared to organic field farmworkers (110.9 ± 13.6) |  | *Association with decline in eGFR:*  Model 1   * Late harvest (β: - 16.98; 95%CI: −20.22, −13.69)   Model 2   * PSI (β: -0.16; 95% CI: −0.15, −0.06) * Mildly Dehydrated (β: -9.68; 95% CI: −13.31, −3.26) * Dehydrated (β: -13.62; 95% CI: −16.56, −7.71)   Model 3   * Organic field (β: -19.02; 95% CI: −27.29, −10.82 * Conventional field (β: -29.17; 95% CI: −37.26, −21.17)   Model 4   * Organic field (β: -0.23; 95% CI: −0.41, −0.03) for every 1% increase in PSI * Conventional field (β: -0.37; 95% CI: −0.57, −0.16) for every 1% increase in PSI * Mild Dehydration (β: -8.51; 95% CI: −13.98, −3.03) * Dehydration (β: -11.99; 95% CI: −16.88, −7.10) | *Model 2:*   * Daily Water Intake (>4 L)   *Model 3:*   * Insecticide application   *Model 4:*   * Daily Water Intake (>4 L) * Insecticide application |  |
| Lumingu et al. 2009 | Young farmworkers (18) | Age range: 12-35 | * All the final sublingual temperatures were under 38°C * Only 4 cases showed sweating that reached 5% of body weight * Mean heart rate was below threshold when WBGT was <28 °C and exceeded threshold when WBGT was >43 °C |  |  |  |  |
| Lundgren et al. 2014 | Agricultural workers (4) | 1 Male  3 Female  Age range: not specified | * Predicted time to reach a core temperature of 38°C was 240 minute in agriculture for females * Average metabolic rate was 190 while doing the following work tasks: Preparation of land for cultivation, sowing, watering, weeding, pest control, fertilization, crop maintenance and harvesting, bending, walking speed 2.45.5 km/h |  |  |  |  |
| Luque et al. 2019 | Hispanic farmworkers (29) | 15 males  14 females  Age range: >19 |  |  | * Farmworkers working under contractual arrangements were less likely to take sufficient breaks and worked for long hours * Focus groups agreed that inexperienced or new workers in the fields are at higher risk for HRIs since they had not had time to acclimatize to the weather conditions |  | * Used a variety of PPE including protective clothing, such as caps, gloves, long sleeve shirts and pants * Brought their own water since they did not like the odor or taste of the tap water at the worksite * Drank electrolyte solutions or Gatorade * Rested in the shade * Used wet cool cloths |
| Luque et al. 2020 | Hispanic farmworkers (101) | 61 males  40 females  Age range: 19-66 | * 19% of participants reported HRI symptoms   *HRI symptoms reported:*   * 2% dizziness * 5% skin rash * 1% muscle cramps * 4% light-headedness * 14% headache * 12% heavy sweating * 3% extreme weakness * 3% nausea * 1% dry skin |  |  |  | *Type of beverages ingested:*   * 89% water * 64% Gatorade * 19% energy drinks * 27% fruit juice * 12% coffee or tea * 26% Soda * 2% Beer * 58% began with a few hours of work before starting to work a full day * 77% used shade under trees * 20% used shade structures * 13% used fans * 10% used rest stations * 11% wore wet hats or bandannas * 66% drank more water * 21% changed work hours * 2% used a vehicle with air conditioning * 23% changed work activities * 23% took rest breaks in the shade   *Clothing always or usually worn:*   * 23% light-colored short-sleeved shirt * 3% dark-colored short-sleeved shirt * 79% light-colored long-sleeved shirt * 5% dark-colored long-sleeved shirt * 5% shorts * 83% pants * 24% jacket   *Head protection always or usually worn:*   * 85% baseball cap * 22% wide-brimmed hat * 3% other hat * 60% bandanna * 8% hood from sweatshirt |
| Mac et al. 2016 | Fernery workers (40) | 13 males  30 females  Age range: 18-54 | * Body core temperature exceeded 38.0°C on 57% of the 86 workdays examined * 30 out of 40 participants had core body temperature that exceeded 38.0°C at least one workday |  | *Associated with an increase in the odds of the body temperature reaching or exceeding 38.0°C:*   * Females (OR 5.38, 95% CI 1.58,18.30) compared to males * Workday energy expenditure (OR 1.12, 95% CI 1.03, 1.21) | * Age * BMI * Body mass * Body surface area * Years working in ferneries * Average WBGT * Workday duration |  |
| Mac et al. 2019 | Fernery workers (40) | 13 males  30 females  Age range: 18-54 | * Body core temperature exceeded 38.0°C on 57% of the 86 workdays examined * 30 out of 40 participants had core body temperature that exceeded 38.0°C at least one workday |  | *Associated with an increase in the odds of the body temperature reaching or exceeding 38.0°C (bivariate models):*   * Total workday energy expenditure (kcal) (OR: 1.08; 95% CI 1.01, 1.15)   *Associated with an increase in the odds of the body temperature reaching or exceeding 38.0°C (multivariate models):*   * Females (OR 5.38, 95% CI 1.58,18.30) compared to males * Workday energy expenditure (OR 1.12, 95% CI 1.03, 1.21) | *Bivariate model:*   * Female sex * Age * BMI * Body mass * Body surface area * Years working in ferneries * Average WBGT * Workday duration   *Multivariate model:*   * Age * BMI * Body mass * Body surface area * Years working in ferneries * Average WBGT   Workday duration |  |
| Miller, 1982 | Tractor driver (1) | Gender: Male  Age range: not specified | * Resting pulse increased from 72 per minute to 140 per minute * Skin temperature increased to 38.4 °C * Sweat loss was 2.54 kg |  |  |  |  |
| Mirabelli et al. (2010) | Latino farmworkers (281)  H-2A workers:177  Non-H2-A workers: 104 | Gender: Not specified  Age range: 18-65 | * 40 % of participants working in extreme heat reported at least one HRI symptom * 31% of H-2A workers reported HRI compared to 56% of non-H2A workers | *Associated with lower HRI:*   * Change work hours and activities among H-2A workers (PR = 0.44, 95% CI=0.22, 0.89) | *Associated with higher HRI:*   * Change work hours and activities among non–H-2A workers (PR=1.11, 95% CI=0.79, 1.55) | Among both H-2A and non-H-2A workers:   * Drink more water * Rest in shaded areas * Go to air-conditioned   places during or after work | * Change work hours (35% H2-A workers vs 40% non-H2-A workers) * Change work activities (30% vs 41%) * Change hours and activities (29% vs 39%) * Drink more water (97% vs 99%) * Take rest breaks in shaded areas (73% vs 93%) * Go to air-conditioned places during breaks or after work (<1% vs 5%)   Change hours or activities (35% vs 43%) |
| Mitchell et al. 2017 | Farmworkers (588) | 389 males  198 females  Age range: 18 – 82 | * 8.3% experienced a body temperature of ≥ 38.5°C * 11.8% experienced dehydration (loss of more than 1.5% of body weight) * 18% exceeded threshold for heart rate for 5 minutes or more |  |  |  |  |
| Mix et al. 2018 | Agricultural workers (192) | 76 males  116 females  Mean age: 38.0;8.2 | * 33% of participants had AKI on at least one workday * 53% of workers were dehydrated (USG 1.020) pre-shift and 81% post-shift * 3% had USG > 1.030) preshift, indicating a clinically dehydrated state which increased to 13%, post-shift * 31% of participants had at least 1 day with a creatinine level above sex specific limits or an increase of 0.3 mg/dL during the day |  | *Association with higher AKI:*   * Heat index (OR=1.47, 95% CI: 1.14 to 1.90) | * Age * Gender * Nationality * Education * BMI * Hypertension * Blood pressure * Diabetes * Work type * Years worked in agriculture * Hours worked per day * Drinks more sports drinks at work * Drinks more energy drinks at work * Drinks more juice at work * Drinks more soda at work | *Type of beverages consumed:*   * 98% water * 69% sports drinks * 50% soda * 39% juice * 16% energy drinks * 9% coffee * 2% alcohol |
| Mohammadian et al. 2020 | Date harvesting workers (59) | Mean Age: 39.3  Male: 36  Female: 23 | * Average systolic blood pressure was 117.81 * Average diastolic blood pressure was 76.01 * Average physiological strain index (PSI) was 2.28 * Average perceptual strain index (PeSI) was 6.61 |  | *Association with PSI:*   * WBGT (correlation coefficient 0.43) * ESI (0.59) * DI (0.60) | * No significant relationship between environmental indices and PeSI |  |
| Moyce et al. 2016 | Agricultural  workers (295) | Male: 190  Female:105 | * 35 participants (11.8%) after a single work shift had cumulative incidence of AKI (stage 1 or stage 2) |  | *Association with AKI:*   * Piece-rate work (AOR 4.52, 95% CI 1.61 to 12.70) | * Sex * Age * BMI * Diabetes status * Blood pressure * Level of education * Years in agricultural work * Farm task |  |
| Moyce et al. 2017 | Agricultural workers (283) | 182 males  101 females  Age range: > 18 | * 12.4% of participants had AKI * AKI was present in 12.1% among men and 12.9% among females * 11.7% experienced heat strain among those who had AKI * 64.8% of men and 52.5% of women lost <1.5% body mass | *Association with lower AKI:*   * Obesity (OR 0.29, 95% CI 0.10 to 0.82) * Overweight men (OR 0.29, 95% CI 0.08 to 0.97) * Obese men (OR 0.25, 95% CI 0.07 to 0.94) | *Association with higher AKI:*   * Heat strain among men (OR 1.31, 95% CI 1.01 to 1.70) * Piece rate work (OR 4.24, 95% CI 1.56 to 11.52) * Piece rate work among females (OR 102.81, 95% CI 7.32 to 1443.20) * Years in agricultural work among females (OR 1.12, 95% CI 1.01 to 1.24) | * Volume depletion (% body mass lost) * Age * Gender * BMI * Diabetes * Blood pressure * History of kidney disease * Farm task |  |
| Moyce et al. 2019 | Agricultural workers (471) | 298 males  173 females  Age range: >18 | * 14.9% of participants had AKI (indicated by increase in serum creatinine of ≥0.3 mg/dL or ≥1.5 times the preshift creatinine) after a single day of agricultural work * 36% had elevations of core body temperature ≥1°C |  | *Association with higher AKI:*   * Workload (1.92; 95% CI 1.05‐3.51) * Piece‐rate work (3.02; 95% CI, 1.44‐6.34) | * Age * Gender * Diabetes * BMI * Blood pressure * History of kidney disease * Max daily WBGT * Years in agricultural work * Farm task |  |
| Moyce et al. 2020 | Agricultural workers  (445) | 283 males  162 females  Age range: >18 | *Compared to females, more males:*   * Experienced AKI (15.9% vs 12.9%) * Had a change in core body temperature that was greater than or equal to 1°C (131 vs 39) * Lost at least 1.5% of their body mass (dehydration indicator) (43 vs 4) |  | *Association with higher odds of AKI:*   * Total volume consumed (AOR 1.47, 95% CI= 1,.9–1.99) * Maximum workload (1.01, 95% CI 1.01–1.02). * Picking (AOR 2.51, 95% CI 1.39–4.54) * Male with diabetes (AOR 6.76, 95% CI 1.49–30.77) * Male picking (4.12, 95% CI= 1.87–9.08) | * Age * BMI * Diabetes * Blood pressure * Payment method * Years in agricultural work * Maximum WBGT * Percentage body mass lost * Sugary drinks | * Men drink 2.9L of water compared to 1.9L for women |
| Mutic et al. 2018 | Farmworkers (198) | 78 males  120 females  Age range: 19-54 | * 84% of participants reported experiencing at least one symptom * 40% reported three or more symptoms   *HRI symptoms reported:*   * 66% heavy sweating * 58% headache * 32% dizziness * 30% muscle cramps * 24% nausea/vomiting * 10% fainting * 9% confusion   *Symptoms fell into three latent classes:*   * Mild (heavy sweating; class probability = 54%) * Moderate (heavy sweating, headache, nausea-vomiting and dizziness; 24%) * Severe (excessive sweating, headache, dizziness, nausea-vomiting, sudden muscle cramps and fainting; 22%) |  | *Association with higher odds of HRI:*   * Female (OR = 2.86, 95% CI 1.18–6.89) | * Age * Nationality * BMI * Reported hypertension or diabetes * Education * Alcohol * Smoking * Work type * Days worked per week * Hours worked per day |  |
| Nanayakkara et al. 2020 | Paddy farmers (25) | Male: 25  Age: 23-64 | * 12% and 4% of farmers in the morning had dehydration in non-farming and farming seasons respectively according to urine osmolarity * 24% and 40% of farmers in the evening showed dehydration in the non-farming and farming seasons respectively urine osmolarity * 88% and 72% of farmers in the morning had dehydration in non-farming and farming seasons respectively according to plasma osmolarity * 2% and 40% of farmers in the evening had dehydration in non-farming and farming seasons respectively according to plasma osmolarity |  |  |  |  |
| Nayha et al. 2017 | Working population (4007)  Agriculture: 136 (3.4%) | 1860 males  2147 females  Age range: 25-74 |  |  | *Association with higher odds of cardiorespiratory symptoms:*   * Working in agriculture (OR 2.27; 1.14–4.46) compared with working in industry |  |  |
| Pogacar et al. 2017 | Farmers (230) | 143 males  87 females  Age not specified | *HRI symptoms reported:*   * Headache (women 64% vs men 46% %) * Exhaustion (69% vs 56%) * Nausea or vomiting (19% vs 8 %) * Fainting (11% vs 6%) * Prickly heat (8 % vs 13 %) * Muscle cramps (2 % vs 6 %) * Heat cramps (0 % vs 0.7 %) |  |  |  | * 79% drank more water * 44% change to lighter/less clothing * 54% took breaks in cooler areas * 34% took more breaks * 73% adjusted work schedule |
| Pundee et al. 2021 | Sugarcane farmers (98)  Sugarcane cutters (150) | Male: 37  Female: 61  Male: 66  Female: 84 | * % Cross-shift change in urine creatinine (92.7% vs 85.65%) * Post-shift NGAL (8.93 vs 11.35) * %Cross-shift change in NGAL (182% vs 112%) |  | *Association with higher post-shift NGAL (univariate analysis)*   * Sugarcane cutter (OR: 0.42; 95% CI: 0.22–0.71) * Working hour (4.6–8.45 h) (OR: 0.41; 95% CI: 0.19–0.87)   *Association with higher post-shift ACR (multivariate analysis)*  Water intake ≤ recommendation (OR: 5.33; 95% CI: 1.04, 27.33) | *Association with higher post-shift ACR*   * Sugarcane cutter (reference: Sugarcane farmers) * Working hours * Water intake > recommendation   *Association with higher post-shift NGAL*   * Sugarcane cutter (reference: Sugarcane farmers) * Working hours * Water intake > recommendation * Water intake ≤ recommendation | * 36% of males consume the recommended amount of water (>3.7L) * 74% of females consume the recommended amount of water (>2.7L) |
| Quandt et al. 2008 | Migrant Latino farmworkers (304) | 300 males  4 females  Age range: 18-70 | * Effects on skin related quality of life (QOL) measured using the Dermatology Life Quality Index (DLQI) were reported in 38.7% of observation |  | *Engaging in specific work tasks was associated with elevated DLQI*   * Planting (OR: 4.16, CI 2.53–6.84) * Cultivating (OR: 2.39, CI 1.17–4.86) * Tobacco topping (OR: CI 2.44, 1.44-4.13) * Harvesting (OR: 2.20, CI 1.46–3.31)   *Working in higher temperatures was associated with elevated DLQI*   * Working in temperatures > 23.9°C and ≤26.7°C (OR: 2.29, CI 1.21–4.36) * Working in temperatures >26.7°C (OR: 3.33, CI 1.37–8.12) | * Self-rated health * Barning tobacco |  |
| Raines et al. 2014 | People with occupational history in agriculture (151 out of a total sample 424) | 166 males  258 females  Age range: 15–69 | * 77% of agricultural workers had reduced eGFR |  | *Association with reduced GFR among current or former agricultural workers (univariate analysis):*   * Male sex (p <0.001) * Lifetime days cutting or harvesting crops (p=0.004) * Lifetime days cutting or harvesting sugarcane (p=0.005) * Lifetime hours cutting or harvesting sugarcane in the dry season (p=0.001)   *Association with reduced GFR among agricultural workers (multivariate analysis):*   * Any lifetime history cutting sugarcane during the dry season (OR 4.07, 95% CI 1.32–12.58) * Pesticide inhalation (3.14, 95% CI 1.12–8.78) * Sugarcane chewing (OR 3.12, 95% CI 1.21–8.04) * Daily bolis at work (OR 1.48, 95% CI 1.02–2.14) | *Univariate analysis:*   * Hypertension * Age * Diabetes * Nephrotoxic medications * Smoking * Fructose intake * Sugary beverage intake * Daily bolis at work * Water consumption * Alcohol consumption * Lifetime days seeding * Lifetime days watering * Lifetime days mixing pesticides * Lifetime days applying pesticides * Lifetime days working in fields with pesticide use * Inhaled pesticides * Cane chewing * Worked near burning sugarcane   *Multivariate analysis:*   * Age * Male sex * Systolic blood pressure * Alcohol consumption * >365 lifetime days harvesting any crop |  |
| Rajewski et al. 2008 | Agricultural worker (1) | 1 male  Age: 56 | * Male agricultural worker working in the field for about 8 hrs without breaks, fluid intake and no PPE died of heat stroke.   *Examination of patient revealed:*   * Red skin * Body temperature: 41.2 ° C * Heart rate: 160 / min * Blood pressure: 130/80 mm Hg |  |  |  |  |
| Raju et al. 2014 | CKD Patients (198)  Renal insufficiency (656) | Mean age: 46.64 (11.63) | * 24% of CKD patients were agricultural workers * Reduced GFR with increasing age   *CKD patients compared to controls:*   * Significant decrease (p<0.001) in creatinine clearance * Increase in blood urea (98.77 vs 28.55 mg/dl) * Increase in serum creatinine (4.6 vs 0.9 mg/dl) |  |  |  |  |
| Ricco et al. 2017 | Pesticide applicators (131) | 107 males  24 females  Age range: > 18 | * 41.2% of participants reported 3 or more symptoms * 93.1% had at least one symptom   *HRI symptoms reported:*   * 79.6% profuse sweating * 29.0% asthenia * 8.4% confusion, feeling disoriented * 8.4% nausea and/or vomiting * 13.8% high heart rate * 37.4% headache * 15.3% dizziness * 23.7% fainting, rapid breathing * 8.4% blurred vision * 7.7% sudden loss of postural tone without even temporary loss of consciousness * 3.1% sudden loss of postural tone with even temporary loss of consciousness |  | *Associated with higher HRI (univariate analysis):*   * Female sex (OR 3.632, 95%CI 1.392–9.135) * Being a professional farmer (OR 2.438, 95%CI 1.168–5.058) * Drink at least one glass of water every working shift (OR 0.059, 95%CI 0.016–0.211 * Drink at least five glasses of water every working shift (OR 2.753, 95%CI 1.327–5.709) * Alcohol consumption (OR 3.339, 95%CI 1.513–7.367) * Take rest breaks in shady, not air-conditioned areas (OR 4.174, 95%CI 1.473–11.828) * Perform pesticide application (OR 2.705, 95%CI 1.296–5.646) * Manual hoeing/weeding (OR 2.975, 95%CI 1.185–42.035)   *Associated with higher HRI (multivariate analysis):*   * Manual hoeing/ weeding (OR:8.847 95% CI 1.882–41.579) * Pesticide application (OR 8.847, 95% CI 1.882–41.579) * Rests in shady, not air-conditioned areas (OR:5.491 95% CI 1.372–21.971) | *Univariate analysis:*   * Age * Seniority * Migration background * Education * ≥ 3 days a week * Seeding * Harvesting/Picking * Machine operation * Irrigation * Hoeing/weeding, mechanized * Pruning * Previous training about high temperatures * Drink more water * Take rest breaks in cooler, air-conditioned areas * Increased number and/or frequency of rest breaks * Anticipate/Delay hours of work activities   *Multivariate analysis:*   * Age * Female sex * Seniority * Migration background * Education * Being a professional farmer * ≥ 3 days a week * Seeding * Harvesting/Picking * Machine operation * Irrigation * Hoeing/weeding, mechanized * Pruning * Previous training about high temperatures * Drink at least one glass of water every working shift * Drink at least five glasses of water every working shift * Alcohol consumption * Drink more water * Take rest breaks in cooler, air-conditioned areas * Increased number and/or frequency of rest breaks * Anticipate/Delay hours of work activities | * 38.9% received HRI training during the previous 5 years * 90.8% drank water * 78.6% took rest breaks in shady, not air conditioned areas * 23.7% took rest breaks in cooler, air-conditioner areas * 66.4% increased number and/or frequency of rest breaks * 77.1% anticipated/delayed hours of work activities   *Sun protection behavior:*   * 72.5% used head protection * 61.1% used sunscreen * 93.1% used long sleeves shirts * 89.3% used specific clothes * 84.7% used sunglasses |
| Sadiq et al. 2019 | Maize farmers (396) | 251 males  145 females  Age range: 15-60 | *HRI symptoms reported everyday:*   * 93.2% heavy sweating * 48.5% tiredness * 34.1% dizziness * 40.4% headache * 29.8% heat rash/pricking * 25.3% rapid pulse * 33.8% nausea/ vomiting * 19.7% elevated body temperature * 9.8% muscle cramp * 11.1% fainting |  |  |  |  |
| Sahu et al. 2013 | Rice harvesters (124) | 124 males  Age range:18-45 | *Physiological symptoms:*   * Heart rate recovery is fast in low temperature and slow in high temperature after work period indicating cardiovascular strain * Higher peak heart rate, sum of recovery heart beats and cardiac cost variables with increasing temperature   *HRI symptoms reported:*   * 37% discomfort * 50% heat exhaustion * 72% pain in different body parts |  |  |  |  |
| Sandsund et al.2021 | Fish farmers (14) | Age range: 16-64  Male:13  Female:1 | * Minimum Tc was 37.1 ± 0.2 °C * Maximum Tc was 38.1 ± 0.2 °C * Skin temperatures ranged from 18 °C (front thigh) to 35 °C (chest) |  |  |  |  |
| Sen & Nag 2019 | Farmworkers (1144) | Males:632  Females:512  Age range: 30-50 | * 1/3 complained of moderate to high intensity of back pain, muscle pain and heavy sweating. * Females had more marked heat-related symptoms compared to males * 11% and 6% of female and male farmers, respectively had symptoms of tachycardia, dizziness, headache, and blurring of vision |  |  |  |  |
| Silpasuwan et al. 2020 | Salt farmworkers (120) | Mean Age: 49.5  Female: 73  Male:47 | *HRI symptoms*   * Heat stroke (everyday 0, someday 6.6, never 93.4) * Heat cramps 0.9, 15.1, 84.0) * Heat rash (0.9, 20.8, 77.4) * Heat exhaustion (0, 49.1, 50.9) |  | *Association with healthy skin*   * Heat Exposure (β: 0.35, p=0.01) |  |  |
| Smith et al. 2020 | Migrant farmworkers (60) | 49 males  11 females  Age range: 18-51 | * 68% of participants had one or more HRI symptoms * 12% had 3 or more symptoms   *HRI symptoms reported:*   * 50% heavy sweating * 25% cramps * 22% headache * 10% dizziness * 3% nausea |  |  |  | * 43.76% drank water * Mean liquid consumption was 72.95 oz per day, which is much less than the recommended 32 oz per hour |
| Sorensen et al. 2019 | Sugarcane workers  (105) | Age range: >18 | * Average decline in cross-shift eGFR was 21.8% * 31% to 51% of workers had post-shift serum osmolality less than 280mmol/kg * Average albumin to creatinine ratio (ACR) ranged from 9 to 22mg/mg pre-shift to 18 to 30mg/mg post-shift and only increased significantly across the work shift in March |  | *Association with reduced cross-shift GFR (univariate analysis):*   * Age (estimate -0.3, p<0.01) * Harvests worked (-0.5, p<0.01) * HbA1c (-7.8, p=0.02) * BUN (-0.9, p <0.01) * Serum osmolality (-0.3, p= 0.01) * Pre-shift urine specific gravity (-2.6, p<0.01) * Post-shift urine specific gravity (-3.3, p<0.01)   *Association with reduced cross-shift GFR among post-shift biomarkers:*   * Average WBGT (-1.6231, p=0.03) * Increasing age (-0.4177, p<0.01)   *Association with reduced cross-shift GFR among pre-shift biomarkers:*   * Diabetes indicator HbA1c (-7.35, p=0.04) * Increasing Age (-0.26, p= 0.04) | *Univariate analysis:*   * Highland * BMI * Hypertension * NSAID * Smoking * Preshift GFR * Average WBGT * Maximum WBGT * Cane harvested on study day/previous day * Urine biomarkers (   *Multivariate analysis among pre-shift biomarkers:*   * Hypertension * Pre-shift GFR * Pre-shift specific gravity   *Multivariate analysis among post-shift biomarkers:*   * HbA1c * Osmolality |  |
| Spector et al. 2015 | Crop workers (97) | 51 male  46 female  Age range: > 18 | * 1/3 participants reported HRI symptoms which include dizziness/light-headedness and heavy sweating | *Associated with lower HRI:*   * + Age (OR = 0.92; 95% CI=0.87–0.98) | *Associated with higher HRI:*   * Piece rate (OR = 6.20; 95% CI = 1.11–34.54) * Walking for more than 3 minutes to get to the toilet (OR = 4.86; 95% CI = 1.18–20.06) | * Male * BMI * Diabetes mellitus and/or antihypertensive medication use * Good/fair general health * No HRI Training * No light-colored shirt * Drank caffeine * Drank less than every 30 minutes * Heat index * No Extra breaks * Hard/very hard work | * 57% drank water every 30 minutes in the past week * More than 75% wore a light-colored shirt |
| Spector et al. 2018 | Harvesters (46) | 39 males  7 females  Mean age: 39.1;14.1 | * Mean pre-shift urine specific gravity was 1.025 which is considered minimal dehydration * 24% exhibited excessive sleepiness   *Significant decrease across shift*   * PVT mean reaction time (t [43] = 3.4, p=0.002) * Number of lapses (t[43]= 2.3, p=0.029) * Mean path length for both eyes open (t[45]= 3.8, p < 0.001) and eyes closed (t[45]= 3.1, p= 0.004) |  |  | * Heat exposure was not associated with impaired vigilance or balance |  |
| Stoecklin-Maroi et al. 2013 | Farmworkers (467) | 263 males  211 females  Age range: 18-55 |  |  |  |  | * 91% received HRI training (87.5% male vs 96.7% female, p=0.0003) * 29.7% of workers bring their own water to work (44.9% vs 10.5%) * Workers drank 10.7 times/ day employer provided beverages (11.1 vs 10.3) |
| Stoklosa et al. 2020 | Migrant Agricultural Worker (1) | Male  Age: 25 | * Elevated creatinine level (3.9 mg/dL) * Serum potassium level of 5.2 mmol/L * Mildly elevated total creatine kinase (219 U/L) * The diagnoses were heat exhaustion, severe dehydration, and renal insufficiency   *Symptoms included:*   * Lightheadedness * Blurred vision * Fasciculation * Nausea * Vomiting * Abdominal cramping |  |  |  |  |
| Trevisan et al. 2019 | Sugarcane workers (32) | 32 males  Mean age: 47.4 | * Rhinitis symptoms were (53.4%) compared to the non-harvesting period (26.7%, p = 0.039) and 6 months after the beginning of harvesting (20%, p = 0.0006) * Significant increase in IL-6 (inflammatory marker) after 3 months of harvesting compared to non-harvesting period (p = 0.012) |  |  |  |  |
| Vega‐Arroyo et al. 2018 | Farmworkers (259) | 168 males  91 females  Age range: >18 | * 45% had a body temperature greater or equal to 38°C * 15% percent of workers were hypohydrated based on loss of 1.5% of body fat |  | *Association with higher CBT:*   * Work rate (β = .006, 95% CI [0.004, 0.009]) * WBGT (β = .03, 95% CI [0.017, 0.05]) | * Gender * Age * Clothing ensemble insulation heat gain * Hydration status (weight loss) * Head gear insulation heat gain |  |
| Venugopal et al. 2021 | Agricultural workers (223) | Mean age: 43.7  Male: 44  Female: 179 | * 9.8% had increase in CBT greater than 1 °C * 4.1% had sweat rate above safe limit for more than 1 l/h * 2.2% had increase in urine specific gravity * 93.7% had HRI symptoms * 73.1% had dehydration * 45.2% had urogenital issues |  |  |  |  |
| Wagoner et al. 2020 | Farmworkers (28) | Age range: >18 | * Mean S.G.s of post-shift March, June and August were 1.25, 1.025, and 1.02, respectively * 40% of June post-shift samples were clinically dehydrated and 57% were mildly dehydrated * The percentage of time workers’ core body temperatures were over the 38 °C was minimal * Body temperatures between 37 °C and 38 °C made up over 80% of the workdays |  |  |  |  |
| Wegman et al. 2018 | Sugarcane workers (80)  Intervention group (Inland): 40  Nonintervention group (Coastland): 40 | Age range: 18-63  Intervention group:  39 males  1 female  Nonintervention group:  28 males  12 females | *Decrease in cross harvest GFR:*   * Intervention group −3.4 ml/min/1.73m2 (95% CI, −5.5 to −1.3) * Nonintervention group -5.3 (95% CI -7.9 to -2.7) * Compared to inland group, more workers had eGFR <60 in the Coastland group at baseline (5 versus 2), and at the end of the harvest (7 versus 2) * Comparing group differences in eGFR (ie, changes from baseline to end of harvest) showed a smaller decrease in the inland group compared with the coastland group that was close to significant; 2.8 percentage points (95% CI -1.1–6.5) |  |  |  |  |
| Wesseling et al. (2016a) | Sugarcane workers (29) | 29 males  Age range: 17–38 | *Cross harvest changes in pre-shift biomarkers:*   * 10% decrease in GFR * 16% increase in creatinine * 40% increase in serum urea N * 4 times increase in NGAL |  |  |  |  |
| Wesseling et al. (2016b) | Three working population groups  (194)  Construction workers: 56  Sugarcane cutters: 86  Small-scale  farmers: 52 | 194 male  Age range: 17–39 | * Reduced eGFR (<80 mL/min/1.73 m2) (sugarcane cutters 16% vs farmers 2%) * Proteinuria >30 mg/dL (14.7% vs 6.1%) * SCr >1.2 mg/dL (17.4% vs 5.8%) * BUN >20 mg/dL (15.1% vs 1.9%) * Leucocyturia (22.1% vs 1.9%) | *Association with improved GFR among sugarcane cutters:*   * Electrolyte solution (β 8.1, 95% CI −1.2 to 17.5, p=0.09) | *Association with reduced GFR among all workers and restricted to sugarcane cutters (univariate analysis):*   * Work as a sugarcane cutter (p=0.007) * High intake of water (p=0.007) * Low intake of sugary beverages (p=0.007) * Increasing age (p=0.002) * Low haemoglobin (p=0.001) * High tobacco consumption (p=0.02)   *Association with reduced GFR among sugarcane workers (univariate analysis):*   * Cumulative time in job   *Association with reduced GFR among all workers:*   * + Age (β −1.3, 95% CI −1.8 to −0.8; p<0.001) * Serum uric acid (mg/dL) (β -10.4, 95% CI −12.2 to −8.5)   *Association with reduced GFR among sugarcane cutters:*   * Age (β −1.9, 95% CI −2.7 to −1.1, p<0.001) * Serum uric acid (mg/dL) (β -11.3, 95% CI -14 to -8.6) | *Association with reduced GFR among all workers and restricted to sugarcane cutters (univariate analysis):*   * Work day (hours), median * Hours cutting cane, median * Total break time (min), median * Breaks ≤2/d, % (# cases) * No shade during breaks, % * High speed perception, % * Production (tons/d), median * Incentives to cut more, % * History of pesticide use * Total fluid intake (L), median * Low total fluid intake * High total fluid intake * Water (L), median * Low water intake * Sugary beverage, median * High sugary drink intake * Intake electrolyte solution * Hypertension * BMI * Alcohol * Nephrotoxic medication   *Association with reduced GFR among all workers and restricted to sugarcane cutters (multivariate analysis):*   * Sugarcane cutter ever * Cumulative time in job * Work day (hours), median * Hours cutting cane, median * Total break time (min), median * Breaks ≤2/d, % (# cases) * No shade during breaks, % * High speed perception, % * Production (tons/d), median (10%; 90%) * Incentives to cut more, % * History of pesticide use * Total fluid intake (L), median * Low total fluid intake * High total fluid intake * Water (L), median * Low water intake * High water intake * Sugary beverage, median * Low sugary drink intake * High sugary drink intake * Hypertension * BMI * Tobacco * Alcohol * Nephrotoxic medication |  |
| Wilmsen et al. 2019 | Latino forestry workers (23) | Mean age: 30 | * One worker had heat illness and didn’t achieve full recovery |  |  |  |  |

**List of included articles**

1. Arcury, T. A., Arnold, T. J., Quandt, S. A., Chen, H., Kearney, G. D., Sandberg, J. C., . . . Daniel, S. S. (2019). Health and Occupational Injury Experienced by Latinx Child Farmworkers in North Carolina, USA. International Journal of Environmental Research & Public Health [Electronic Resource], 17(1), 30.
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